# tech engineering news

december 1954

**Robert L. Schneider, class of '49,**
**speaks from experience when he says . . .**

# "United States Steel offers unlimited opportunities covering practically all engineering fields"

IN 1949 Robert L. Schneider graduated from college with degrees in engineering and physics. After being interviewed by United States Steel, he was accepted as a trainee. Then after a year, he was advanced to a test engineer in the Maintenance Department; then to a power foreman in the Power & Fuel Division. By 1953, he had been made Power Superintendent in the Power & Fuel Division at the Carrie Furnaces.

As superintendent, he is responsible for the operation and maintenance of power producing and distributing facilities for the plant which supplies electrical power to several of our largest steel mills around Pittsburgh. Such advancement is not unusual at U.S. Steel.

As for the future, Schneider says, "Opportunities are unlimited. U.S. Steel is such a large and diversified organization that the future is not restricted to your current department or division. Transfer to equal or better positions in numerous other divisions is always possible."

To all future graduate engineers Mr. Schneider says, "U.S. Steel offers the best opportunity to get an overall picture of and experience in industry today. U.S. Steel is big enough to cover practically all engineering fields and permits a man to find the fields he wants to pursue."

If you are interested in a challenging and rewarding career with United States Steel and feel that you can qualify, you can obtain further details from your college placement director. Or we will gladly send you our informative booklet, "Paths of Opportunity," upon request. Just write to United States Steel Corporation, Personnel Division, Room 1628, 525 William Penn Place, Pittsburgh 30, Pa.

**SEE THE UNITED STATES STEEL HOUR** It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

USS

# UNITED STATES STEEL

AMERICAN BRIDGE . . AMERICAN STEEL & WIRE and CYCLONE FENCE . . COLUMBIA-GENEVA STEEL . . CONSOLIDATED WESTERN STEEL . . GERRARD STEEL STRAPPING . . NATIONAL TUBE
OIL WELL SUPPLY . . TENNESSEE COAL & IRON . . UNITED STATES STEEL PRODUCTS . . UNITED STATES STEEL SUPPLY . . *Divisions of* UNITED STATES STEEL CORPORATION, PITTSBURGH
UNITED STATES STEEL HOMES, INC. • UNION SUPPLY COMPANY • UNITED STATES STEEL EXPORT COMPANY • UNIVERSAL ATLAS CEMENT COMPANY 4-1892

# QUARTZ CRYSTALS

## *How a 1¼ hour "gem-cutting" operation became an 8-minute mechanized job*

**PROBLEM:** Preparing quartz crystals for use as electronic frequency controls calls for the highest degree of precision. So much so, in fact, that prior to World War II skilled gem-cutters were employed to do the job.

But during the war, there were not enough gem-cutters to keep up with the demand for crystals in radar, military communications and other applications.

Western Electric tackled the job of building into machines the skill and precision that had previously called for the most highly skilled operators.

**SOLUTION:** Here is how quartz crystals are made now—by semi-skilled labor in a fraction of the time formerly required:

A quartz stone is sliced into wafers on a reciprocating diamond-edged saw, after determination of optical and electrical axes by means of an oil bath and an X-ray machine. Hairline accuracy is assured by an orienting fixture.

The wafers are cut into rectangles on machines equipped with diamond saws. The human element is practically eliminated by means of adjustable stops and other semi-automatic features.

The quartz rectangles are lapped automatically to a thickness tolerance of plus or minus .0001". A timer prevents overlapping. Finally, edges are ground to specific length and width dimensions on machines with fully automatic microfeed systems.

Most of these machines were either completely or largely designed and developed by Western Electric engineers.

**RESULTS:** With skill built into the machines —with costly hand operations eliminated— this Western Electric mechanization program raised production of quartz crystals from a few thousand a year to nearly a million a month during the war years. This is just one of the many unusual jobs undertaken and solved by Western Electric engineers.

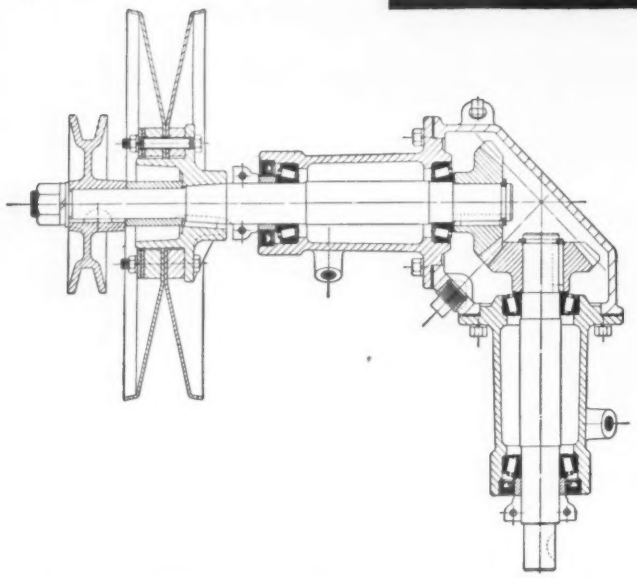
*Quartz stones are cut into wafers on this diamond-edged saw, with orientation to optical axis controlled by fixture. This is just one of several types of machines designed and developed by Western Electric engineers to mechanize quartz cutting.*

Western Electric

A UNIT OF THE BELL SYSTEM SINCE 1882

Manufacturing plants in Chicago, Ill.; Kearny, N. J.; Baltimore, Md.; Indianapolis, Ind.; Allentown and Laureldale, Pa.; Burlington, Greensboro and Winston-Salem, N. C.; Buffalo, N. Y.; Haverhill and Lawrence, Mass.; Lincoln, Neb.; St. Paul and Duluth, Minn. Distributing Centers in 29 cities and Installation headquarters in 15 cities. Company headquarters, 195 Broadway, New York City.

*Another page for* **YOUR BEARING NOTEBOOK**

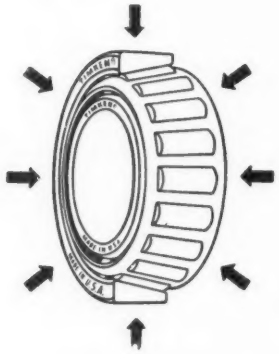


## How to increase bevel gear life

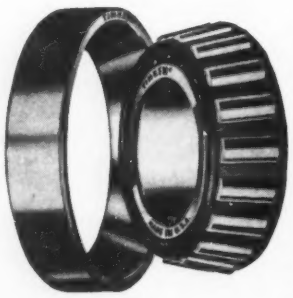
The shafts that hold the bevel gears in this farm machine gear box carry two kinds of loads. Loads from the bevel gears run 1) along the shaft and 2) at right angles to it. Timken® bearings, being *tapered*, carry both loads at once, hold gears rigidly in place. Perfect tooth-mesh is maintained; gears last longer.

## How TIMKEN® bearings hold shafts rigid

The line contact between rollers and races of Timken bearings gives shafts rigid support over a wide area. Shaft deflection is minimized. And end-play is eliminated because the tapered design of Timken bearings lets them take radial and thrust loads in any combination.



**TIMKEN**
TRADE-MARK REG. U. S. PAT. OFF.
*TAPERED ROLLER BEARINGS*



## Want to learn more about bearings or job opportunities?

Many of the engineering problems you'll face after graduation will involve bearing applications. For help in learning more about bearings, write for the 270-page General Information Manual on Timken bearings. And for information about the excellent job opportunities at the Timken Company, write for a copy of "This Is Timken". The Timken Roller Bearing Company, Canton 6, Ohio.

NOT JUST A BALL ○ NOT JUST A ROLLER ⬭ THE TIMKEN TAPERED ROLLER ⬭
BEARING TAKES RADIAL ⓞ AND THRUST —ⓞ— LOADS OR ANY COMBINATION —ⓞ—

The Lockheed Missile Systems Division

*announces an advanced study program for*

# MASTER OF SCIENCE DEGREES

University of Southern California • University of California at Los Angeles

**The Lockheed Graduate Study Council** offers an Advanced Study Program to enable exceptionally qualified individuals to obtain Master of Science degrees in prescribed fields. Under this plan the participants are employed in their chosen fields in industry and concurrently pursue graduate study.

**Students who are United States citizens** or members of the Armed Services being honorably separated and holding B.S. Degrees in Physics, Electrical Engineering, Mechanical Engineering, and Aeronautical Engineering are eligible. Candidates must qualify for graduate standing.

**The industrial assignment** will be on the Research and Engineering Staff of Lockheed Missile Systems Division. The Advanced Study Program will be at one of the Universities named above. If sufficient number of qualified students apply, as many as 100 awards will be granted.

**During the regular school year** the industrial assignment will be coordinated with the Study Program to permit a half-time University schedule of advanced study. During the school vacation periods participants will be employed full-time at the Lockheed Missile Systems Division.

**Salaries will be determined** by the individual's qualifications and experience in accordance with accepted current standards. Participants are eligible for health, accident and life insurance as well as other benefits accorded full-time staff members.

**Tuition, admission fees** and costs of textbooks covering the number of units required by the University for a Master of Science Degree, will be borne by Lockheed. A travel and moving allowance will be provided for those residing outside the Southern California area.

**How to apply:**

Contact your placement bureau or write
The Graduate Study Council for an application form
and brochure giving full details of the program.

GRADUATE STUDY COUNCIL

*Lockheed*

MISSILE SYSTEMS DIVISION

LOCKHEED AIRCRAFT CORPORATION

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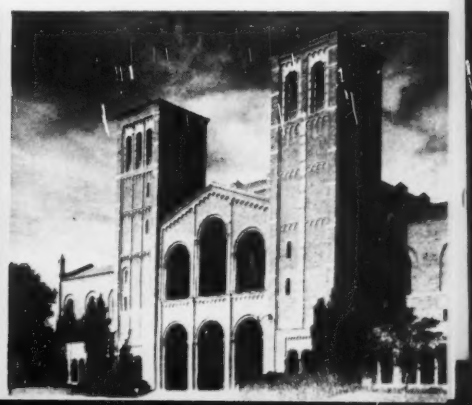

*Wings*

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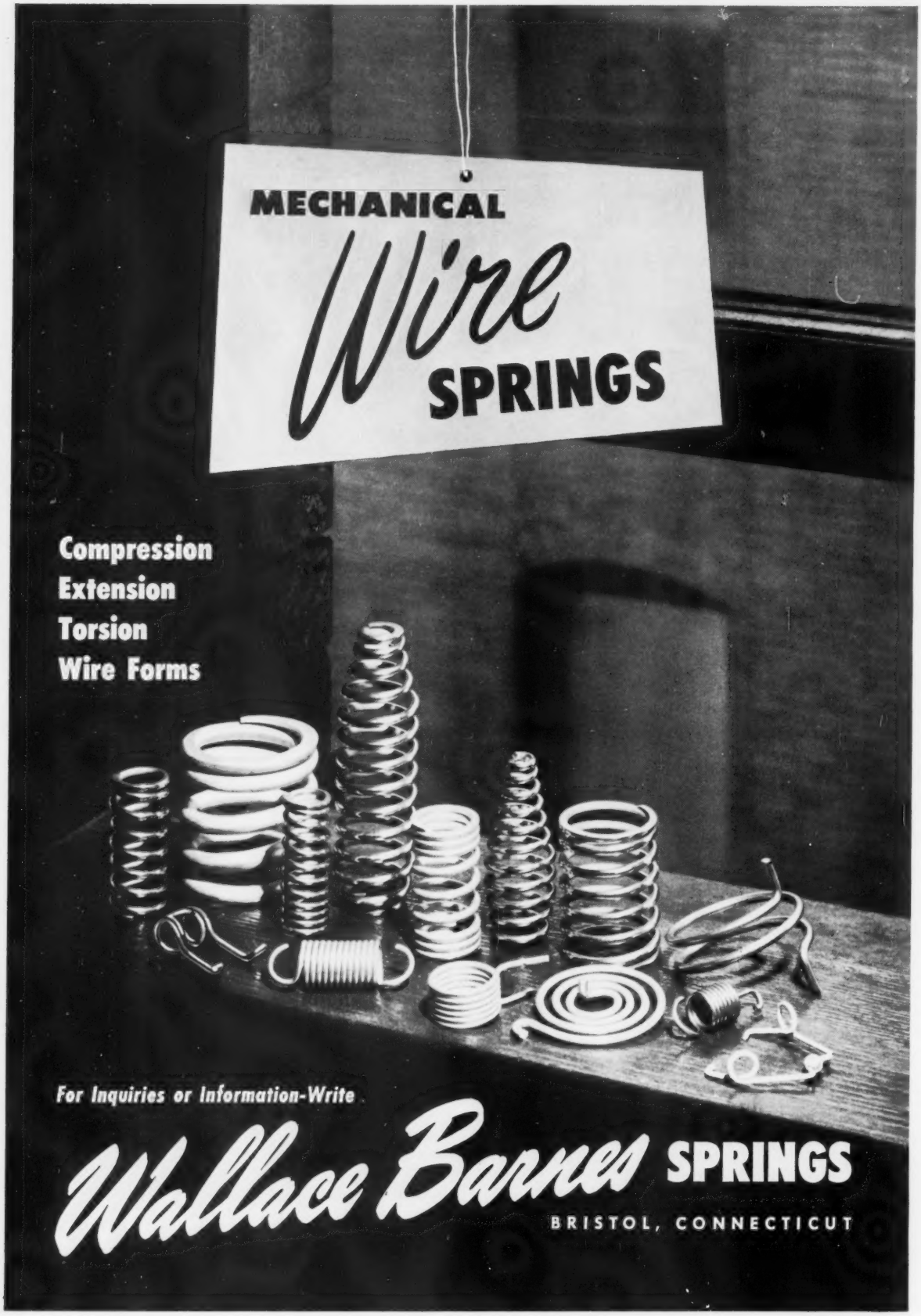
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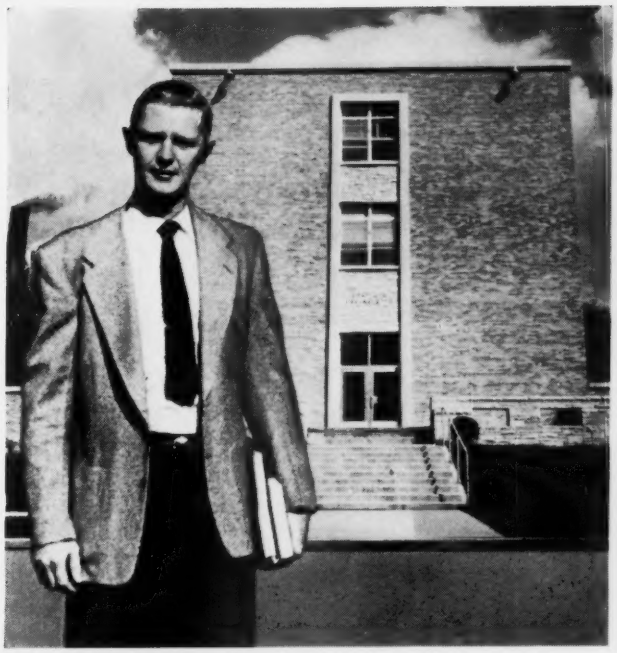


**Delbert N. De Young** received a B.S. in Chem. Eng. from the University of Wisconsin last June. Now he is working for an M.S. degree. By asking questions, he's learned that many excellent industrial opportunities are passed over because they're not understood by the average undergraduate.

*Del De Young wants to know:*

# What sort of work is involved in technical sales at Du Pont?

**Clarence D. Bell,** B.S., Chem. Eng., Univ. of Pitts. (1937), joined Du Pont as a chemical engineer immediately after graduation. He began in the research group of the Ammonia Department, progressed steadily through assignments on nylon and a number of other products. Today he is an Assistant Director of Sales in the Polychemicals Department.

*Clarence "Ding" Bell answers:*

Well, if I said "All sorts," it might sound a bit vague to you, Del, but it would be very close to the truth. That's because technical sales work at Du Pont—bearing in mind the great diversity of products we have—is broader in scope than a lot of other technical assignments, and requires additional talents.

Let's suppose that one of Du Pont's customers is having technical difficulties—needs help in adapting "Teflon" to a specific gasketing application, for example. When our sales representative calls, he naturally must carry with him the engineering knowledge that's the basis for sound technical advice—data on flexural fatigue, chemical passivity, and deformation under load. The customer is receptive. He wants to make a better product, increase his sales, reduce costs—or do all three. Naturally, he's looking for reliable technical advice and intelligent actions that apply to his specific conditions. With the cooperation of the customer and help from our own research people, when necessary, the problem will sooner or later be "licked."

We have found, though, that if a technical service man is going to be *truly* effective in such a situation, he must possess certain *human* qualities in addition to his technical ability. That is, he must really *like* people and be sincerely interested in helping them solve their problems. He must—in every sense of the word—be an "ambassador" who can handle human relationships smoothly and effectively.

Take the depth suggested by this simple example, Del, and multiply it by a breadth representing all the challenging problems you'll run into with Du Pont's diversity of products. If your slide rule isn't too far out of alignment, the resulting area should give you some idea of what I meant by "all sorts" of work.

Let me emphasize one more point. The importance of effective sales work is fully understood and appreciated at Du Pont! In the past, sales work has been one of the active roads to top management jobs. There is every reason to believe that this will continue in the future.

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

WATCH "CAVALCADE OF AMERICA" ON TELEVISION

***Are you inclined*** toward sales work? There are four main types of sales activity in the Du Pont Company—technical sales service, sales development, market research and direct selling. Information on sales, and many other facts about working with Du Pont, are given in "The Du Pont Company and the College Graduate." Write for your copy of this free 36-page booklet to E. I. du Pont de Nemours & Co. (Inc.), 2521 Nemours Building, Wilmington, Delaware.

# computors

Roger D. Wollstadt

Computation for computation's sake does not exist to any great extent. Very few people, for instance, would be interested in calculating to a thousand places. However, practically all scientific and engineering problems can be solved only after detailed numerical calculations. The computed results are in those cases necessary for the attainment of some larger or more important end.

Sometimes, in these calculations, the mathematical relations in question are intricate and involved; at other times, the sheer quantity of material to be handled may seem to constitute an insurmountable obstacle.

In these cases, large-scale computing machines are notoriously useful. They are so useful on important and extensive programs that they justify their relatively great costs. They are easily able to do mathematical work that would otherwise be tedious, involved, or even impossible.

*Digital and Analog Computers*

Any artificial computing device, whether simple or complex, can be considered as one of two types: a "calculating machine", or digital computer; or a "mathematical instrument", or analog computer.

A digital machine handles numbers expressed in digital form to a finite number of significant figures and does calculations with these numbers in a series of discrete steps.

In analog computers, physical quantities, such as voltages or shaft rotations (or linear motions in the case of the slide rule, the simplest analog computer), are made to obey mathematical relations comparable to those in the problem.

Considerable planning must go into the reduction of mathematical operations to arithmetic ones before a digital machine can handle a problem. Furthermore, because intermediate calculations must usually be carried out to more places than are required in the final result, the computing units must be able to deal with large numbers. Consequently, digital computers have their greatest utility in large-scale computational problems that require repetitive operations of high accuracy.

A digital machine has, however, a number of significant advantages over an analog computer. There is no easy way for an analog computer to use alphabetic information given in letters, to express random numbers, to express numbers with an accuracy of more than five or six decimal digits, or to handle problems which require the machine to choose routines which depend on what has happened in the course of a problem. A digital machine can do all these things easily.

*The "Analytical Engine"*

The first ideas in modern automatic calculation were brought forth in the 1830's by Charles Babbage, a professor of mathematics at Cambridge, in his plan for an "analytical engine." The analytical engine was not actually built, due to insufficient advancement in the field of mechanical construction at the time.

The basic plan behind the analytical engine was that the machine could be ordered to carry out any computational direction, at any time, present or remote. For instance, it could be ordered to change a table of squares into a table of cubes the first time the square number ends in the figures 269696; an event which only occurs at the 99736th calculation.

The analytical engine consisted of three units, the store, the mill, and the control unit, which correspond to the basic parts of a modern digital computer.

In the store, numerical information was recorded on counters. The store was designed to have a capacity of 1,000 fifty-digit numbers.

In the mill, numerical operations could be carried out on numbers that had been taken from the store. The mill was capable of doing sixty additions, one multiplication, or one division involving fifty-digit numbers per minute.

The control unit determined the sequence of operations, the selection of numbers, and the disposal of results. These functions were accomplished by means of punched "number cards", which were inserted in the machine and interpreted by devices in it.

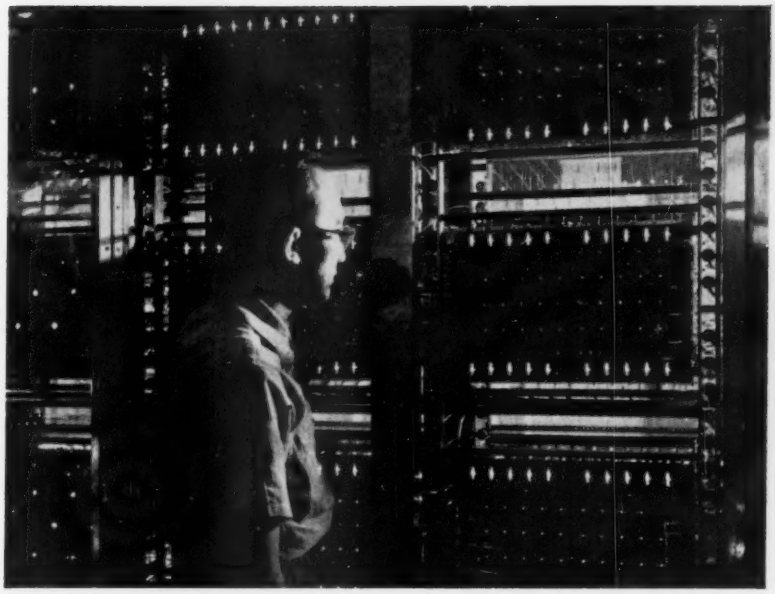
*Mark I*

The first large automatic digital machine constructed was the IBM Automatic Sequence-controlled Calculator (commonly known as Mark I), which was built in 1943-44 at the Computation Laboratory of Harvard University. Mark I uses mechanical counters driven through electromagnetic clutches controlled by relay circuits.

Input in Mark I is handled by IBM punched cards (note the continuation of Babbage's principle); sixty constants, though, may be introduced by manually operated dial switches. Results are

Table 1: *Four-element Codes*

| | Elements | | | | | Elements | | |
|---|---|---|---|---|---|---|---|---|
| Digit | 1 | 2 | 4 | 8 (Binary) | 1 | 2 | 4 | 5 |
| 1 | X | | | | X | | | |
| 2 | | X | | | | X | | |
| 3 | X | X | | | X | X | | |
| 4 | | | X | | | | X | |
| 5 | X | | X | | | | | X |
| 6 | | X | X | | X | | | X |
| 7 | X | X | X | | | X | | X |
| 8 | | | | X | X | X | | X |
| 9 | X | | | X | | | X | X |
| 0 | | X | | X | X | | X | |
| (alt.) 0 | (Blank) | | | | (Blank) | | | |



given out by two automatic electric typewriters and an IBM card punch. These results may be directly copied for publication by photo-lithography, eliminating the need for transcription with its inevitable introduction of errors.

Mark I is able to hold 72 twenty-three-digit numbers or 144 eleven-digit numbers in its storage registers.

*ENIAC*

In 1945, the first practical computer to use vacuum tubes and electronic circuits, the ENIAC (or Electronic Numerical Integrator and Calculator) was built in the Moore School of Electrical Engineering of the University of Pennsylvania.

The ENIAC gave an extremely high computing speed which was not available even in Mark I. It is capable, in one second, of performing 5,000 additions or over 300 multiplications, each involving ten-digit numbers. Furthermore, the ENIAC had the advantage of low access time; it could look up tabular information in a few milliseconds, while Mark I required a full second to compute similar information for its use.

The ENIAC's input, like that of Mark I, is handled by IBM cards, which the machine is able to read at the rate of 800 per second. Its output is handled by a printer and by IBM cards; it is able to give out 800 results per second.

*Mark II and Mark III*

Mark II, the second in the series of electric and electronic computers designed by the Computation Laboratory of Harvard University, was built in 1947. It is an electric computer, as it uses electro-mechanical relays for all important operations, including internal storage of numbers, transfer of numbers, basic arithmetical operations, and sequence control.

Probably the most important basic change incorporated into Mark II was that of input and output by punched paper tapes. The tapes made it possible for results to be reintroduced automatically into the machine. They also provided for additional storage space where high-speed access was not required.

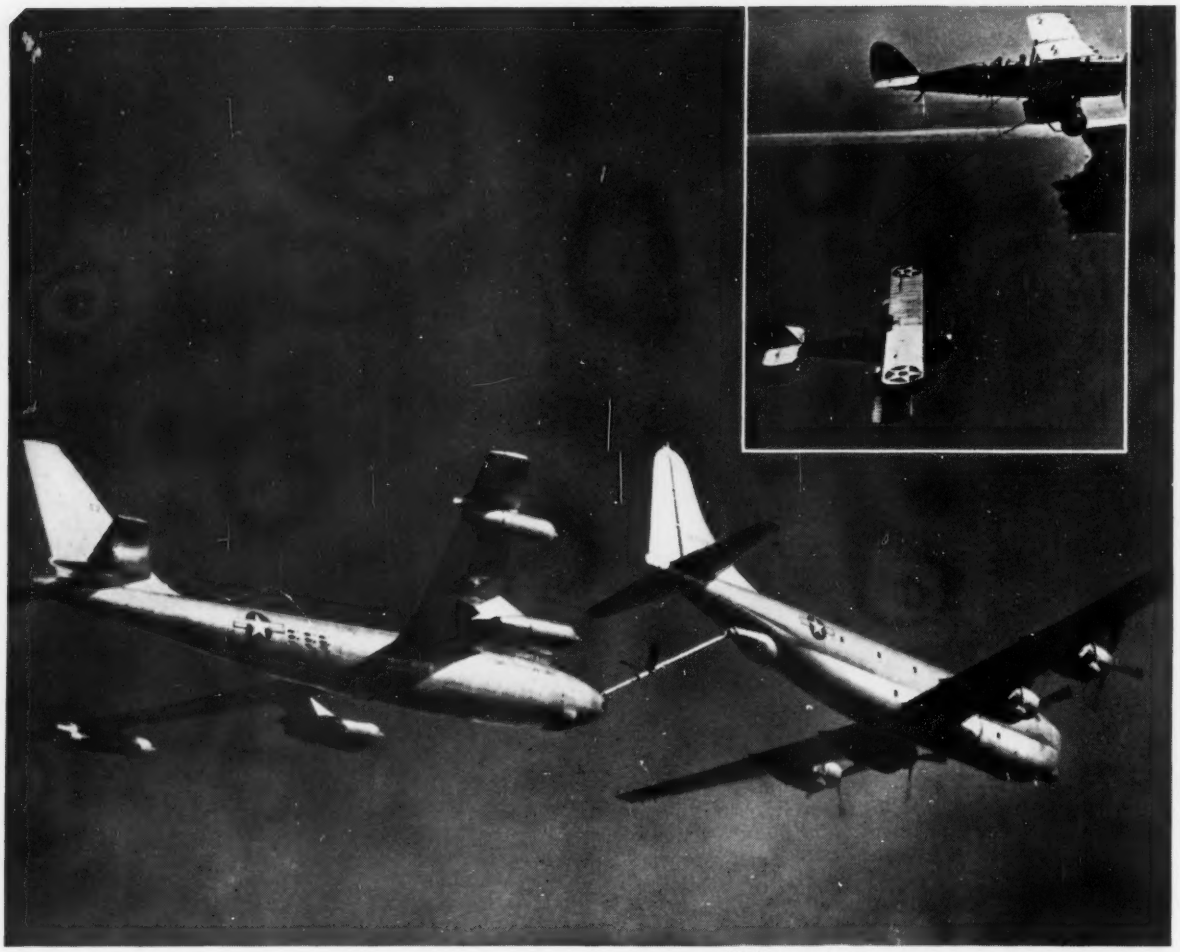
Another concept introduced in Mark II was that of the "floating decimal point." A number X, with floating decimal point is expressed in the form $(p \times 10^j)$, where $1 \quad p \quad 10$ and j is an integer such that $-15 \quad j \quad 15$. This notation made practically all arithmetic operations easier, although it complicated addition and subtraction.

A third major concept introduced in Mark II was that of cyclic operation. Each cycle, which took 0.5 seconds, consisted of thirty orders. For instance, orders No. 3 and No. 4 in each machine cycle have to specify transfers from storage registers to a multiplier, and the initiation of a multiplication. If no multiplication is desired during that particular cycle (which is very unlikely), these two orders are left blank. Because of such restrictions as these, it is possible for the machine to furnish part of each order, and this part need not be stated on the sequence tape.

In 1949, the Harvard Computation Laboratory completed work on Mark III, a giant electronic computer. Through its electronic circuits, it was able to compute at a speed approximately fifty times as great as that of Mark II.

Storage in Mark III was accomplished by impressing the numbers electrically on a rotating magnetic drum. This form of storage, which can be read only when the impression passed in front

| Computer | Multi. time (Milliseconds) | Numbers in Memory | Memory Device |
|---|---|---|---|
| Mark I | 5,500 | 75 | Mechanical |
| Mark II | 700 | 100 | Relays |
| Mark III | 12 | 200 | Magnetic Drum |
| ENIAC | 2.8 | 130 | Electron Tubes |
| BINAC | 1.2 | 500 | Mercury "Delay Line" |
| Bell Tel. Labs. V. | 2,000 | 30 | Relays |
| Whirlwind I (MIT) | 0.06 | 2,000 | Electrostatic |
| Engineering Research Associates | 15 | 18,000 | Magnetic Drum |

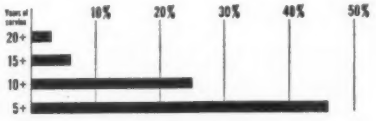


**1954**—Boeing KC-97 tankers completed 16,000 refuelings last year

## 30 years of progress in aerial refueling

The small picture shows the first aerial refueling by the Air Force. The large picture shows a Boeing KC-97, today's standard Air Force tanker, transferring 600 gallons of fuel a minute to a Boeing B-47 Stratojet bomber.

Boeing pioneered aerial refueling tankers and equipment. Further, during its 38 years, it has constantly pioneered trend-setting designs in commercial and military aircraft. This has meant such continuous growth that Boeing now employs more engineers than ever before, including the World War II peak. Boeing offers *stable* careers to engineers of virtually EVERY type: civil, mechanical, electrical and aeronautical. The company employs draftsmen and engineering aides for routine work, thus freeing engineers for more creative assignments.




Boeing engineers enjoy long-range careers—46% of them have been at Boeing 5 or more years, 25% have been here 10 years, and 6% for 15 years.

In addition to stability, Boeing offers an unusual variety of research, design and production opportunities, including work with new materials, guided missiles, jet bombers and transports, and research in nuclear-powered aircraft and supersonic flight.

Boeing makes it possible for engineers to take graduate studies while working, and reimburses them for all tuition expenses.

***For further Boeing career information, consult your Placement Office, or write:***

**JOHN C. SANDERS, Staff Engineer—Personnel**
**Boeing Airplane Company, Seattle 14, Wash.**

**BOEING**
SEATTLE, WASHINGTON WICHITA, KANSAS

Table 2: *Self-checking Codes*

| | Two-out-of-five Elements | | | | | Bi-quinary Elements | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Digit | 0 | 1 | 2 | 4 | 7 | 00 | 5 | 0 | 1 | 2 | 3 | 4 |
| 1 | X | X | | | | X | | | X | | | |
| 2 | X | | X | | | X | | | | X | | |
| 3 | | X | X | | | X | | | | | X | |
| 4 | X | | | X | | X | | | | | | X |
| 5 | | X | | X | | | X | X | | | | |
| 6 | | | X | X | | | X | | X | | | |
| 7 | X | | | | X | | X | | | X | | |
| 8 | | X | | | X | | X | | | | X | |
| 9 | | | X | | X | | X | | | | | X |
| 0 | | | | X | X | X | X | | | | | |

of a scanning device, is known as dynamic storage. Although it is more complicated, it is much more efficient in the use of relays or tubes.

*Whirlwind I*

In digital computers, numbers are transferred and used in two ways, either serially or parallelly. In serial operation, each digit of a number is acted upon separately and in its proper order. In Parallel operation, all digits are operated upon simultaneously. In electric computers, in which each step takes considerable time, parallel operation is usually used. In electronic computers, however, each step usually requires only a few milliseconds. Serial operation is generally used in them, at a considerable saving in equipment.

However, the MIT Whirlwind, completed in 1950 and located in the Barta Building, is an electronic computer which uses parallel operation. It is, therefore, able to do almost 20,000 multiplications per second and is the world's fastest computer.

*Number Systems*

In a digital computer, it is generally preferable to represent numbers by a system which has only two elements. One method of representing numbers this way is the binary system. The binary system has only two elements, 0 and 1, which are coefficients of successive powers of two. For example, the binary number 110101 represents $2^5$ $2^4$ $2^2$ $2^0$ or 53. The binary system has the advantage of being the most economical with computer components.

On the other hand, the use of such elements does not necessitate the use of the binary system. Decimal numbers may also be represented by a set of such elements. One way this can be done is by taking ten of these elements and using them one at a time, one standing for each digit. This method is used in the ENIAC.

Another way, which is used in Mark II, is to simply represent each digit in binary form. This requires only four elements per digit, one to three of which are used at a time. There are also other codes for representing each digit as a combination of up to three out of four elements. (See table 1.)

Still other calculators, notably the Bell Telephone Laboratories' relay calculators, use self-checking codes. (See table 2.) At least five elements are necessary to provide ten self-checking combinations for the decimal digits. In the two-out-of-five code, two and only two elements are used for one digit. If more or less than two digits come up, the machine stops and corrects itself.

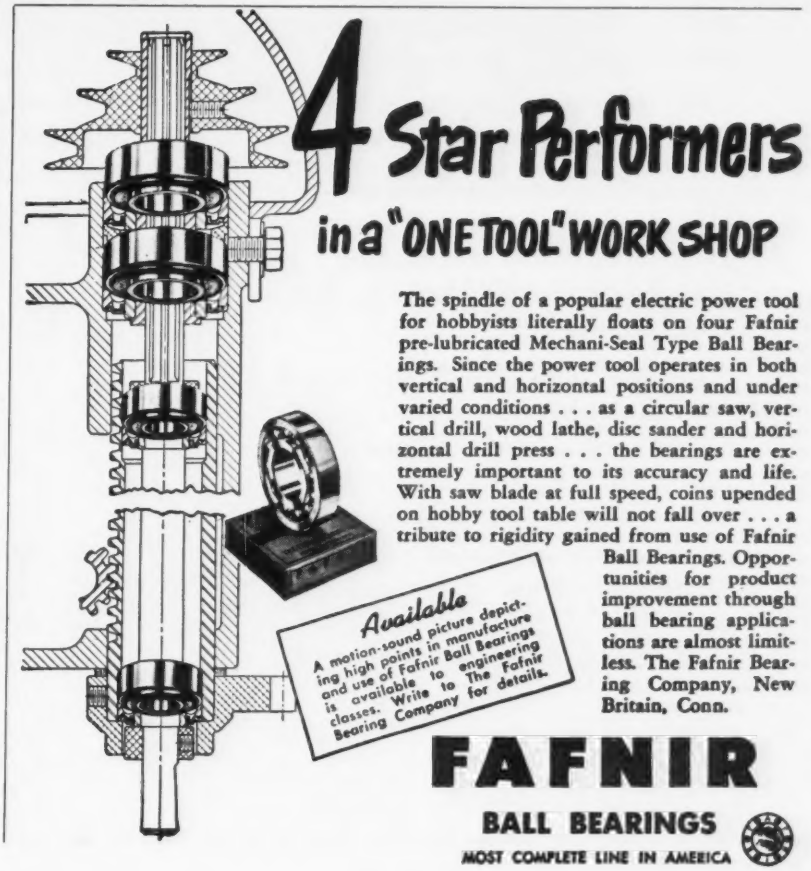
In the bi-quinary system, the check is even more complete. Each digit must be represented by two of the seven elements, one and only one of which must be either 00 or 5. A dishonest but correct representation can be obtained only when two particular troubles are present simultaneously. The probability of two such simultaneous troubles is extremely remote.

*Comparison of Digital Computers*

The multiplication time is the best single criterion for comparing computer speed. In most problems, the speed of multiplication and the number of single operations required for a solution give a good approximation of the time required for a solution.

The high-speed memory is that part of the memory which is immediately available for use. It does not include auxiliary memory devices such as Mark II's punched tapes.

The included table compares these two factors in several representative digital computers. It also names the device used in the high-speed memory.



4 Star Performers
in a "ONE TOOL" WORK SHOP
The spindle of a popular electric power tool for hobbyists literally floats on four Fafnir pre-lubricated Mechani-Seal Type Ball Bearings. Since the power tool operates in both vertical and horizontal positions and under varied conditions . . . as a circular saw, vertical drill, wood lathe, disc sander and horizontal drill press . . . the bearings are extremely important to its accuracy and life. With saw blade at full speed, coins upended on hobby tool table will not fall over . . . a tribute to rigidity gained from use of Fafnir Ball Bearings. Opportunities for product improvement through ball bearing applications are almost limitless. The Fafnir Bearing Company, New Britain, Conn.
Available
A motion-sound picture depicting high points in manufacture and use of Fafnir Ball Bearings is available to engineering classes. Write to The Fafnir Bearing Company for details.
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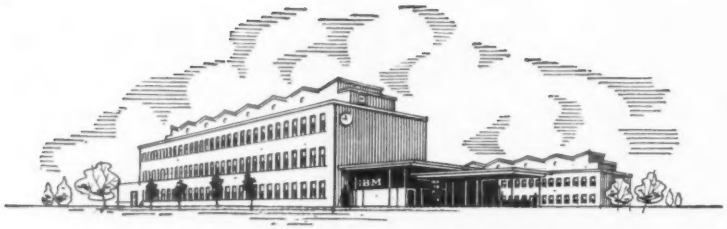

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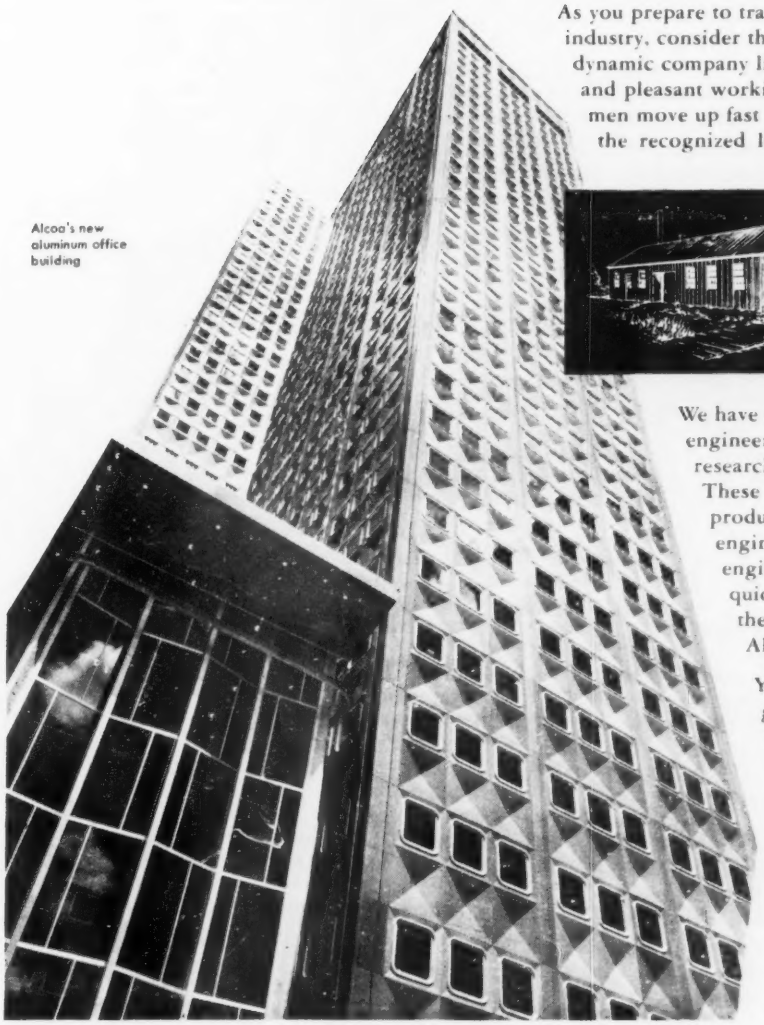

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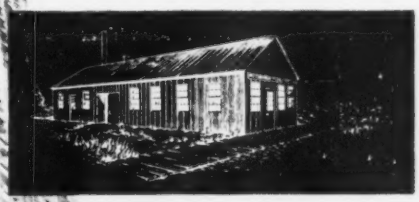

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# from the editor's notebook

*Here's an editorial to make you think. What effect do parents, industry, the "Times," the Institute, do I, have on my education? This letter was written by an M.I.T. freshman, a man who tasted defeat on muddy Briggs Field, a man you may see passing you in the corridor every day. Why has the Institute impressed him in this way? Is he right in his beliefs, or is the Institute? That's for you to decide . . . and the Institute. Some premises are undoubtedly true while others require a more careful analysis before they can be judged. Read this editorial; I think the thoughts provoked are worth a few minutes of your time.*

It hasn't been too long since those individuals destined to be forever after uniquely described by the blanket phrase, class of '58, surveyed an endless chain of academic VIP's welcoming them to the Institute. After living in the Institute for ten weeks, it should be interesting to sum up some general impressions; How does the freshman feel about college life at MIT? Has any radical change overcome him in the past few weeks?

Well, this freshman as of yet still hasn't outgrown the bewildered look that markedly distinguishes us from our more experienced colleagues. The buildings have an awesome effect; they mirror the feeling one gets as he walks through rows and rows of endless research labs replete with intricate mazes of scientific apparatus that tell of countless hours of work on the part of the experimenter. One seems to be able to explore the mazes of experimental labs for years without ever seeing the same one twice. There is a very wonderful feeling of devotion—countless men hidden behind wires and test tubes applying their very existence to their work, all working with one goal in mind, all feeling the pulse of nature, all attempting to arrive at his awesome essence. The freshman hasn't gotten over the marvel of it yet . . .

The idea of living in a dormitory, that too hasn't passed by the freshman without leaving its maturing influence of self-dependence.

Freshmen have long since discovered to their delight that there is no such word as inadequacy when it comes to MIT facilities. The pool dazzles most of us, and the music library parallels our boldest dreams in the way of fine reproducing equipment. Most of us have even surmised that insofar as pretty female secretaries are concerned, the MIT clerical staff is unsurpassed.

Everything leads to the jubilation of the freshman, that is, almost everything. For some of us, our jubilation is marred by some little thing that began to gnaw at us a while back. We just couldn't quite grasp what it was at that time that bothered us. It just was slightly discomforting at first, this thing. As time progressed the gnawing became more and more pronounced, until it became quite evident what was the source of our discomfiture. It is the perturbing thought: the congenial environment is welcome, but . . . are we getting an education?

College life surrounds us, and spirit, comradery, traditional rivalries are blatantly present; all of which the faculty correctly remind us are part of "college life." There is one thing, however, that is more inherently part of college life (or should be) than all those things. That is the enlargement of the intellectual dimensions of the men. It is the virtual forcing of students to examine their position in the scheme of things, to incessantly grope for greater and greater understanding of basic problems, to diligently broaden their capacity for artistic and intellectual satisfaction. It is the coercion of the student by exposing him to controversial opinions and by having him establish intimate contact between his thoughts and those of outstanding thinkers, by compelling him to form his own opinions that will eventually enhance his perspective. The vista of his comprehension is ever-increasing. It should be forced to increase, as a direct consequence of his broadened scope, his capacity for aesthetic and spiritual and intellectual enjoyment will be greatly augmented. In the light of this marked change of point of view of the student, and in the light of this increased awareness on the part of the student of his place in society, he then may be qualified to choose his life's work. He should, after being exposed to many fields of endeavor, then be competent to determine which one offers him greatest satisfaction. At least so I once believed.

Unfortunately the *lack* of this philosophical discipline begins to appear before the freshman. He is made to notice the waxing conspicuity of that thought: Am I getting an education?—the thought that continually stings him like the socratic gadfly.

Why does this thought enter into our minds at all? Why is it brought up? Is it that we sense some sort of incompleteness in a program that centers wholly on the technical? Is it that there is something in us which craves intellectual expansion, before the vocational part of us is developed? What is education anyway?

MIT was founded on certain principals. The most notable of them were that there was a growing need for people adequately trained in technology. Another one of its founding propositions seems to be that people who are to be adequately trained in technology can't afford the time to question. They have no time to expand their philosophical dimensions. It is a belief that is extremely prevalent in the Institute. It is one which many students become susceptible to; it is infectious, and one wonders where the infection began.

One wonders . . . Why is such narrow-mindedness fostered? The answer to it does not come easily. After ten weeks of observation it is extremely difficult to correctly criticize, and attach a source to a sore that has slowly magnified until it has reached serious proportions; a sore that in all likelihood has been present ever since the inception of the Institute. Taking that into consideration, I shall, hesitatingly, attempt to answer the question. I believe that that is the inevitable result when an institute of learning sells its intellectual soul. To whom has MIT sold its soul? you ask. The answer is to industry. MIT caters to industry, it appears to me. It seems to be preoccupied with the thought of manufacturing "good" engineers. The flagrant underemphasis of anything that doesn't directly lend towards the production of "good" engineers can be clearly shown as standard procedure at the Institute. MIT has a reputation; and it has to uphold that reputation at all costs the student does not have the time to question . . . And the worst part of it is that the same attitude contaminates the student. Nowhere is there an attempt to analyze a situation, to study a problem of interest for the intellectual stimulus that it provides. Nowhere is there time for that, that is at MIT. The intellectual curiosity of the student is *not* stimulated as it should be. To the contrary, it is allowed to lie dormant because "the students do not have the time for it, and the prime function of MIT is to produce 'good' engineers; to keep up its reputation."

Thorsten Veblen, the economic philosopher, predicted back in 1900 that technology will eventually rule our civilization, and it is as if his prediction is coming true. MIT was founded as an engineering school. As an engineering school, what does it owe to its students?

Most students become engineers today for two primary reasons. They are either beguiled by prestige or money, or both. Too many parents of today urge their sons into engineering because of the prominence the career of engineering enjoys. They seem to be swayed by the full page adds in the Times by engineering firms vouching for the secure future that their sons can have if they go into the field of engineering. The salaries and pension plans offered don't do much to dissuade the parents' determination.

Too few of them seem to realize that the individual is far better off, far happier, and of greater benefit to society if he is well placed in his occupation. They seem to lose sight of the fact that man must create, and derive satisfaction from his endeavors, whatever they are, to really be happy. Man must have that inner attachment after he has completed a work; almost a sense of emptiness after the finishing touches. Life otherwise has no meaning.

In view of this, what does M.I.T. owe to its students? Engineering school educators have a great obligation to their under-graduate body. One of the most serious obligations is to find out whether the student is entering the engineering profession merely because of parental misguidance. Will he find greater happiness at some other profession for which he is better equipped? That certainly is a great obligation. The ultimate molding of a "good" individual should be considered of greater importance than the output of "good" engineers. Indeed, as a consequence of the moulding of broad individuals, the grade of engineer produced will be elevated. How is this to be accomplished?

President Killian once referred to MIT as a Science University, in contradistinction to the usual Liberal Arts University. The real reason for those vital educational problems arising, those problems that I have previously highlighted, is that MIT falls far short of the above analogy. A University is usually considered to be a community of scholars. MIT, unfortunately, is not. It is not so bad that we are engineers—but it is *pitiful* that we are a community *only* of engineers. There is no broad exchanging of opinion between various branches of knowledge. It is not as if you were in contact with students of varied interests, of wide scope of opinion. It's not the same as if a discussion on Political Science could be sparked by someone who might possibly make it his life's study. One can hardly get into such discussions. This

is, in the narrowest sense, a trade school; not that it cannot be improved. Moreover, there is still our first problem to consider. The perturbing question: are we getting an education? It begins to appear that we are not. We are merely being trained. We are being skilled. The courses are concentrated about one central theme: how to become a "good" engineer. There is no break from the vocational. Even more frightening is the fact that the courses presented require no thinking at all! They are merely vocational.

What is bred, then, is an intellectual indolence, a lethargy. No one is at all particularly interested in awaking from their lethargy either, in expanding from the confines of their vocational shell. What the students need is something to get them off their behind, mentally—something to start them thinking and broadening their point of view.

The Institute has sold its intellectual soul to industry . . . That seems to be the current trend in education ever since endowments by industrialists. The Institute seems to be run by industry and forsakes the improvement of the spiritual and intellectual fiber of the undergrad for it.

But how is this going to be accomplished?—what about the Science University? What would such a thing consist of? Well, it would offer degrees in the arts, philosophy, government, etc., and the sciences, with a core around the sciences. It would be replete, though, with substantial courses in the humanities and languages and engineering. Our main interest, *at all times*, is the extent that the individual can benefit from such a course. The man who finds that he is interested in mathematical philosophy will benefit in his residence at the university by grasping his place in the technical society of today. Such an understanding should be inculcated by a university or college. The man who finds that he derives satisfaction out of engineering, has reached that conclusion after experiencing and coming into close contact with various fields of human accomplishment. He has turned, then, to engineering with greater conviction in that he has seen by experience that engineering offers him greatest satisfaction. He also does not go away with a disdain for theoretical and artistic accomplishments. In a word, he is the broader individual for it. Indeed, such an educational community is a necessity to bridge the ever widening gap between technology and art and theory. President Killian was quite correct when he said that the world was in dire need of a university based around a core of scientific courses. He announced the coming of it, however, a bit prematurely!

The reasons for the inadequacy of the technological college seem to be inherent, almost by definition, in the prime function for setting up such a college. It is to serve the ever-hungry appetite of advancing industry for technologically-stuffed personnel. Oswald Spengler, the historian, saw the machine and technics as overpowering and eventually mastering man. In the economic vein this is truly the situation in which we find ourselves. Our technological advances have grown and grown, and in the process of growing require more and more men to keep them going. Economically, that means that the bait to lure these men into technology gets more and more desirable; hence industry continually raises the salaries and uses more and more glowing and adulatory adjectives to describe the service that the engineer performs for society. It is a monster that we have created, where industry can, at will, control the values, and distort the ideals, and the goal of education. To subdue it, man must once again assert his mastery over the machine, and technology. He must free himself from the rule of the slide rule!

. . . And who must initiate this revolution of man over the slide rule? Again I maintain: It is the responsibility of the educators. There is a growing exigency for the re-valuation of technological education; it is imperative that it face itself squarely and appraise its own worth. Does this type of education develop the noble intellectual qualities of man? Does it make him think?—at least long enough for him to decide whether he might not be more creative in some other field — at least long enough for him to decide whether he is blindly falling for the bait put out by industry, or he has a feeling for the work. Does it develop an aware individual who can appreciate all the things life has to offer . . . or does it merely produce human sacrifices to the insatiable stomach of the technological "monster"?

It is the burden of the educators to compel man to rise above the technological slave he is today.

As a direct consequence—they will produce better engineers, they will have attained a technology that is stable and fruitful, they will have regained the equilibrium of their sense of material values. More important, however, than all of those: they will have elevated man to the position where he will be able to derive more out of life.

Those are my general surmises and observations after ten weeks of higher learning . . .

*Barry Mazur*

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**AUSTIN BUSH,** inspecting stuffing box assembly on boiler feed pump.

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# the hatchet planimeter

Guiseppe Jones

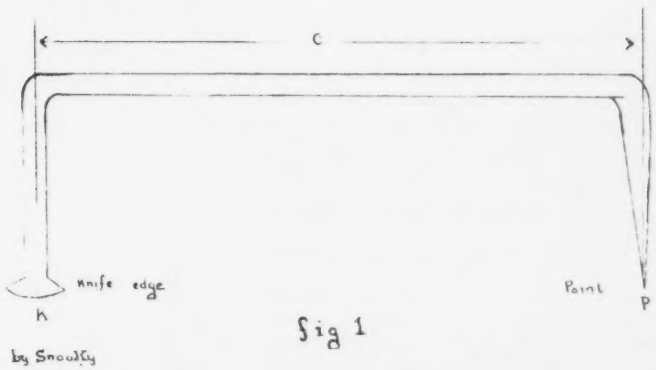



Fig 1

The hatchet planimeter is a simple one piece instrument which can be used to easily measure areas of regular and irregular figures with fairly high precision. It is simply a metal rod bent in the shape of a wide U, one end of which is pointed and the other end of which is flattened to a hatchet-like edge. (See fig. 1.) Generally the length of the planimeter is ten inches or twenty-five centimeters.

To find the area of any plane figure, the planimeter is placed on the plane with its point over the estimated centroid of the figure, G, and its hatchet resting elsewhere on the surface. (See fig. 2.) The position of the hatchet is noted at $K_1$ and then the pointer is moved over a straight line to the perimeter of the figure, around the perimeter, and then back along the line to the centroid. The hatchet, meanwhile, traces a curve such that the planimeter is always tangent to it. The position of the hatchet is again noted at $K_2$ and the tracing procedure is carried out again but around the perimeter in the opposite direction. The third position, $K_3$ is then noted. The distance of the arc of the circle with center G from the second position, $K_2$, to the average of the first and third positions, $K_1 + K_3$ (which are nearly the same), multiplied by the length of the planimeter, c, is then equal to the area of the figure. Generally, the arc length is almost equal to the chord length, so the area equals the distance between $K_2$ and the point halfway between $K_1$ and $K_3$ times c.

When the area measured is on a paper, the three positions of the hatchet can conveniently be indicated by pressing the hatchet blade into the paper to leave dents. It is useful to have a scale on an arc attached to the planimeter. A two bladed knife (fig. 3) can be used as a planimeter if one blade is considered as the pointer and the other as the hatchet.

The complicated theory of the hatchet planimeter was given by Hill[1] in 1894 and was restated in an easier to follow form by Satterly[2] in 1921. For those readers who do not care to get lost in the proof, evidence is presented here to make the performance of the planimeter seem, at least, reasonable when the length of the planimeter is large compared with the dimensions of the figure, and when the pointer is moved only along the perimeter and only in one direction.

[1]by F. W. Hill, PHILOSOPHICAL MAGAZINE, October, 1894.

[2]THE HATCHET PLANIMETER by John Satterly, UNIVERSITY OF TORONTO STUDIES, MATHEMATICAL SERIES, NO. 2, 1921.

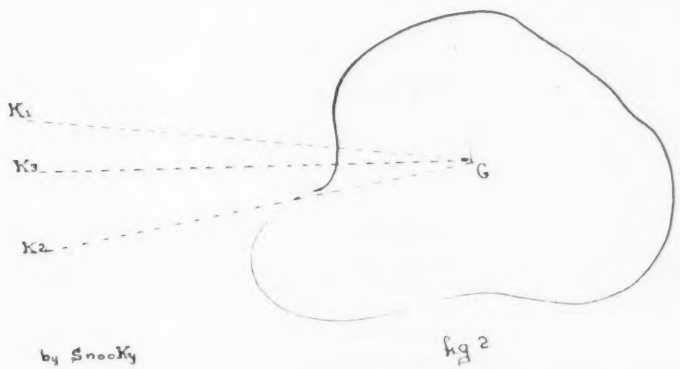
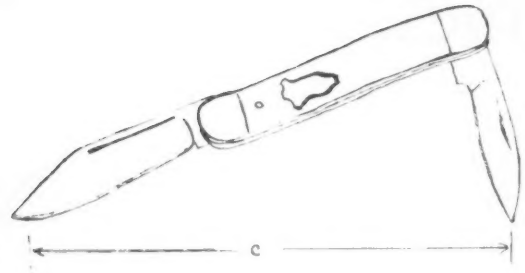



fig 2

Consider first a square of area $a^2$ being measured with a planimeter of length c where

$$c >> a \quad \text{(See fig. 4.)}$$

Let us trace around the square clockwise along $P_1P_2P_3P_4P_1$ while the hatchet describes the curve $K_1K_2K_3K_4K_5$. Let the orientation of the planimeter at $P_1K_1$ be approximately p a r a l l e l to $P_1P_2$ along the x axis. Then as the square is traced the locus of the hatchet is affected as follows, where O is the angle between the planimeter and its original position $P_1K_1$:




by SmoaKy

fig 3

HATCHET DISPLACEMENT

| Path of Pointer | x | y | O |
|---|---|---|---|
| $P_1P_2$ | —a | second order | O |
| $P_2P_3$ | second order | second order | —a/c |
| $P_3P_4$ | a - second order | second order | O |
| $P_4P_1$ | second order | second order | a/c |

Thus, neglecting second order affects, $K_2$ is identical with $K_3$ and $K_4$ is identical with $K_5$. By similar triangles:

$$a/c = a/w$$

Therefore $$wc = a^2.$$

Any irregular figure can be broken up into such elemental squares as in fig. 5. If all squares are traced clockwise, the hatchet deflections caused by the inner edges of the squares cancel each other while the remaining deflections are equivalent to going around the perimeter of the figure. Of course the length of the planimeter must still be large compared with the dimensions of the figure, and consequently the planimeter remains always oriented in approximately the same direction; therefore the arbitrary elemental squares can always be chosen in such a way that two edges of each square are approximately parallel to the planimeter.

Now this reasoning falls apart as the dimensions of the figure approach the length of the planimeter, and effects which in the special case are second order can no longer be neglected. Then the only salvation for the proper understanding of the theory is to dig right into the whole hairy proof, lengthy as it may be. Many will choose to stop here, and be prepared to use the hatchet planimeter in blissful ignorance, but for those intellectual dipsomaniacs who are still dissatisfied, Satterly's paper is recommended.

For those of you who are interested enough to want to see the proof, yet who are too lazy to seek it at a library and yet are not too lazy to fill in the large voids between the equations, here is an outline of Satterly's simplification of Hill's proof:

In fig. 6 the pointer of the planimeter is moved along the x axis from $P_1$ to $P_2$ while the hatchet travels along curve K from $K_1$ to $K_2$. We first find the relation:

$$\tan \alpha/2 = e^{\pi} \tan\alpha/2 \quad \ldots\ldots\ldots\ 1$$

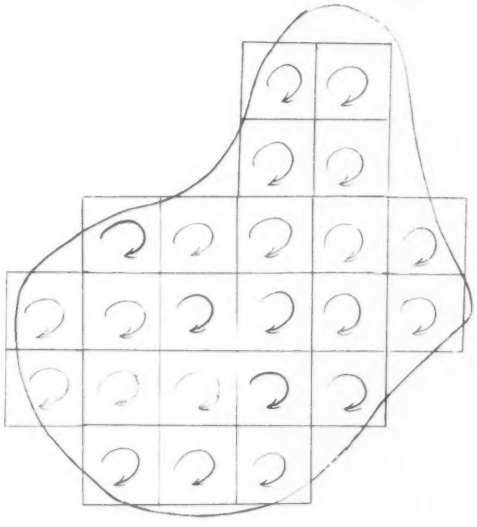


fig 5

by SmoaKy

which is the solution to the differential equation

$$\tan\alpha \frac{dy}{dx} = \frac{d}{dx}(c \sin\alpha)$$

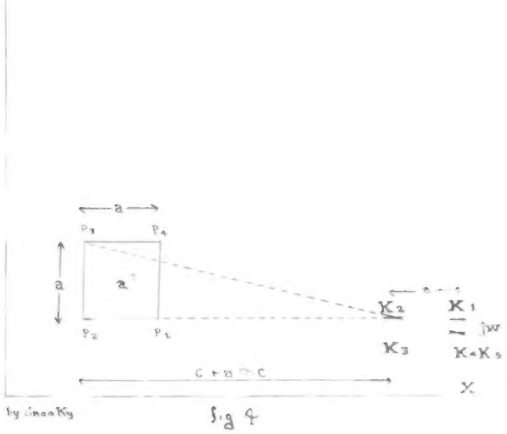
Also taking the log of both sides of (1) and differentiating,

$$\frac{d\alpha'}{\sin\alpha'} = \frac{dr}{c} + \frac{d\alpha}{\sin\alpha} \quad \ldots\ldots\ldots\ 2$$

Tracing along a differential section of the figure in fig. 7, we have the trigonometric relation

$$\frac{d\alpha}{\sin\alpha} = \frac{dr}{c} \quad \ldots\ldots\ldots\ 3$$

Divide the area to be measured into elemental triangles as in fig. 8. Since the hatchet position after trace and retrace from the perimeter to the center is not changed, the area of the figure is measurable if the area of any elementary triangle is measurable.




by SmoaKy

fig 4

For the triangle of fig. 9, the pointer is drawn along the perimeter OPQO while the hatchet traces out $K_1K_2K_3K_4$. In positions $K_1$, $K_2$, $K_3$, and $K_4$ the planimeter has angle of inclination o, $o^1$, $o^1 + do^1$, and o + do. Let OP=r and OQ=r+dr.

Using equation (1) for path OP we get

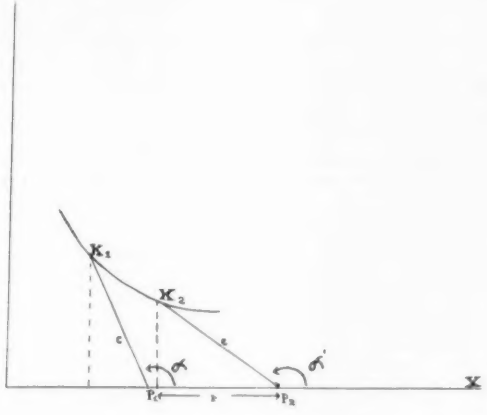
$$\tan\frac{\theta-\phi'}{2} = e^{-\psi}\tan\frac{\theta-\phi}{2} \quad \ldots\ldots\ldots\ldots 4$$

From equation (2) for path OP we get

$$\frac{d\theta-d\phi'}{\sin(\theta-\phi)} = \frac{-dr}{c} + \frac{d\theta-d\phi}{\sin(\theta-\phi)} \quad \ldots\ldots\ldots\ldots 5$$

From equation (3) for path PQ we get

$$\frac{d\phi'}{\sin(\psi+\theta-\phi')} = \frac{ds}{c}$$




by SmooKy fig 6

Since ds sin $\psi$ =rdO, and ds cos $\psi$ =dr we have

$cdo^1 = rdO\cos(O-o^1) + dr\sin(O-o^1)$ ..... 6

$$c\,d\phi' = r\,d\theta\cos(\theta-\phi') + dr\sin(\theta-\phi')$$

Combining equations (4), (5), and (6), straightforward (HAH) mathematical operations gives

$$d\theta - d\phi = \tfrac{1}{2}d\theta\left[(1-r/c)e^{\psi} + (1+r/c)e^{-\psi}\right] + \tfrac{1}{2}d\theta\left[(1-r/c)e^{\psi} - (1+r/c)e^{-\psi}\right]\cos\theta - o \quad \ldots\ldots 7$$

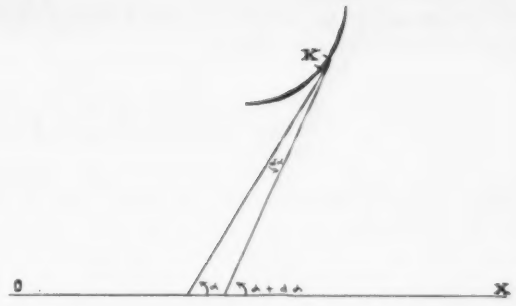
Expanding the exponential terms we find

$$d\phi = d\theta\left[r^2/2c^2 + r^2/8c^4 + r^6/144c^6 + \cdots\right] + d\theta\left[r^3/2c^3 + r^5/30c^5 + \cdots\right]\cos(\theta-\phi)$$

Thus

$$c\int d\phi = \tfrac{1}{2}\int r^2 d\theta + \frac{1}{8c^2}\int r^4 d\theta + \frac{1}{144c^4}\int r^6 d\theta + \cdots + \frac{1}{3c}\int r^3\cos(\theta-\phi)d\theta + \frac{1}{30c^3}\int r^5\cos(\theta-\phi)d\theta + \cdots$$

The term on the left of the above equation,




by SmooKy fig 7

$c^2\int d\theta$, is equal to the length of the planimeter, c, times the arc length, $c\phi$.

The first term on the right, $1/2\int r^2 d\theta = \int 1/2 r^2 d\theta$, is equal to the area of the triangle.

The second term on the right we may write

$$\frac{1}{8c^2}\int r^4 d\theta = \tfrac{1}{2}c^2\int\tfrac{1}{2}r^2 d\theta\,\frac{r^2}{2} = I/2c^2$$

where I is the moment of inertia about the axis perpendicular to the figure through O.

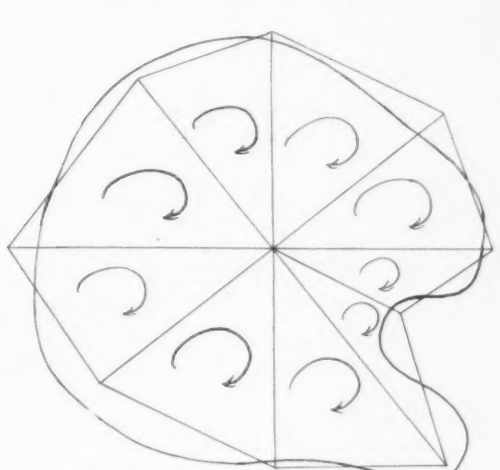
Other terms on the right no involving cosines are negligible. The first cosine term on the right may be written

$$\frac{1}{3c}\int r^3\cos(\theta-\phi)d\theta \approx \frac{1}{3c}\int r^3\cos\theta\,d\theta = \frac{1}{c}\int\tfrac{2}{3}r\cos\theta\,\tfrac{1}{2}r^2 d\theta = \frac{1}{c}A\bar{x}$$

where A is the area, and $\bar{x}$ is the abscissa of the centroid of the triangle.

All other cosine terms on the right are negligible. Thus we have

$$c^2\phi = A + I/2c^2 + A\bar{x}/c + \cdots$$



by SmooKy fig 8

If we choose O as the centroid of a figure made up of such triangles, we have

$$\bar{x} = 0$$

and I has its minimum value according to the parallel axis theorem,

$$I = A e^2$$

where e is the radius of gyration. Therefore

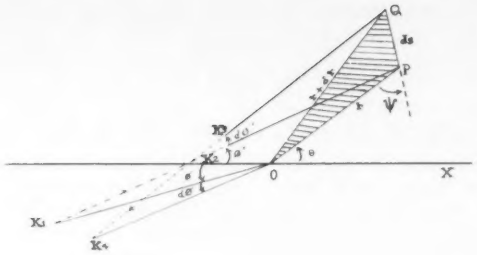
$$c^2\phi = A(1 + e^2/2c^2) \text{ very nearly} \quad \ldots\ldots\ldots 8$$

Now we can see that by estimating the radius of gyration and applying equation (8), the error of overshoot can also be estimated and planimeter measurements can be compensated.

When it is hard to estimate the centroid of the figure, the area may be measured with the planimeter by first letting the hatchet lie to the left of the figure and then letting it lie to the right of he figure. Then

$$\tfrac{1}{2} c^2(\phi_1 + \phi_2) = A(1 + I/2c^2)$$

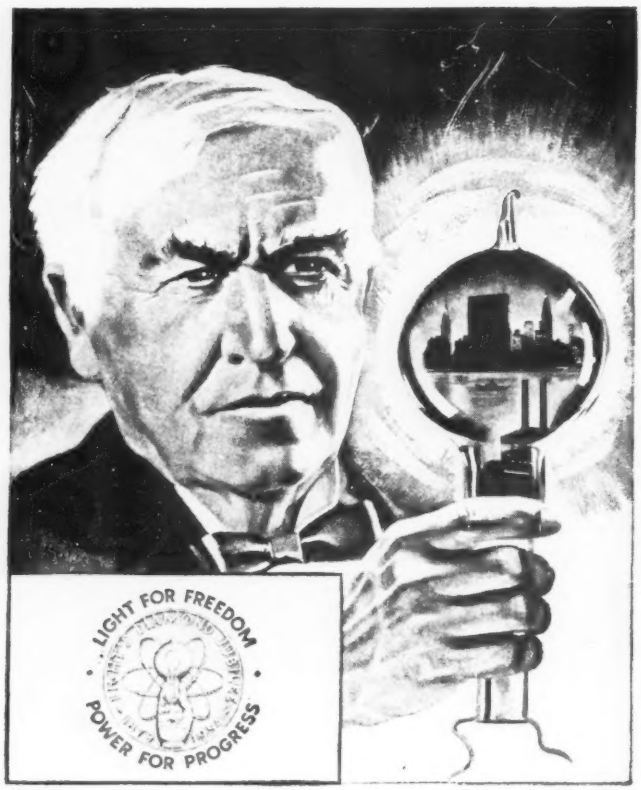
Hill and Satterly conclude that if the greatest possible error in locating the hatchet is 1/8 centimeter, and a 25 centimeter planimeter is used, the formula $c^2\phi = A$ gives the area as accurately as the




by SmoaKy fig 9

nature of the instrument will allow providing the greatest breadth of the figure is no greater than 8 centimeters. This is done by setting the term $e^2/2c^2$ for the circle equal to the error in $c^2\phi$, which would be caused by the maximum possible error of 1/8 in the location of the hatchet. They also conclude that if the area does not exceed 142 square centimeters and 1/8 is again the maximum possible error in the location of the hatchet, the chord distance between the first and second point of the planimeter hatchet is as good as the arc length between the points. This is done by noting the difference between the measurements from the arc and chord must not exceed 1/8, where, by trigonometry, the difference is equal to $c(\phi - 2 \sin \phi/2.)$

Having braved this proof, it is now clear why the hatchet planimeter, as simple as it is, is a device which is capable of a high degree of accuracy. And if you still are skeptical, just try one and see.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# our ocean fisheries- a challenge to technology

Daniel P. Norman '36

New England Spectrochemion Laboratories, Ipswich, Massachusetts

Earth's ever-growing population continues to demand an improved diet and in the foreseeable future there will not be enough productive land available to yield the amount of protein needed for proper nutrition. Increasing attention is therefore being focused on the ocean's resources —the last great untapped source of food. At first glance the ocean's food resources are more than adequate for earth's needs. Recent estimates[1] indicate that some $3x10^{10}$ tons of organic matter are produced annually in the sea, equivalent roughly to $3x10^{11}$ tons of marine animal and vegetable matter. The world's catch of fish is now just under $3x10^{7}$ tons a year, so that there is a potential annual supply of some $3x10^{4}$ tons of food still to be taken from the sea, even without resort to any cultivation.

These figures are most attractive, and many a literary utopia has been based on them. Unfortunately, however, the little item of cost of catching this food sets a firm ceiling on its immediate exploitation. Vast though the ocean's resources are, its volume is even vaster, and the amount of anything, whether food or gold, per gallon is very small. Take gold, for example. There are approximately nine million tons of gold in the sea, and at $35 an ounce its attraction is obvious. If, however, you convert this total to gold per gallon, you find that sea water has only 0.000,000,000,8 ounces of gold per gallon i.e., you would have to process a billion gallons of sea water to recover an ounce of gold.

A great deal of romance and publicity has been given to plankton, the tiny floating animal and vegetable life on which fish live. For every pound of cod living in the ocean there are 10,000 lbs. of animal plankton and 10,000 lbs. of vegetable plankton. Fish, like other animals, are not overly efficient energy converters, and it would be nice to be able to harvest the plankton directly. Unfortunately, again, even in zones of relatively high plankton density, you have to pump 8,000 gallons of water to recover *one ounce* of plankton. It is clearly more economic to let the cod and the haddock do the work of concentrating the plankton and then to catch the concentrated fish. Fortunately for us, life is not uniformly distributed throughout the waters of the world, and the larger forms, the fish, are found bunched in a relatively few localities, where they can be harvested economically.

Scallops, cod, haddock, redfish, herring, sardines, menhaden, are all found at certain seasons in relatively narrow geographical locations where our fishermen have learned by experience to find them. Unfortunately, minor variations in water temperature, salinity, feed distribution and many other factors may markedly alter the pattern of fish concentration, so that the fishermen cannot find them. Despite much progress, the fisherman's basic tools for finding fish are much the same today as they were three centuries ago when the French and Portuguese first began to fish the Grand Banks: experience, intuition, persistence, and luck. In the last two decades, science has taken a hand in the matter, and some new electronic tools are in use.[2] Today Loran is used to fix accurately the position of a rich fishing hole; radar is used to navigate in fogs and improve the safety of fishing in hazardous locations. The many modifications of the echo sounder are used not only to locate good fishing bottoms, but also to locate and identify schools of fish. In the last few months, underwater TV has been used to assist in fisheries studies of the Grand Banks, and may in turn become common on fishing boats, if its price becomes less prohibitive.

Systematic studies in the use of echo sounders for locating and identifying schools of fish were first published in 1935 by Norwegians, who have continued to be leaders in this field. When the studies were first made public, fishermen thought the whole story so improbable that they refused the Norwegian government's offer of technical assistance. As echo sounders became more plentiful in the fishing fleets, European fishermen gradually became convinced of the soundness of the original reports and requested government assistance in locating fish. Today, a Norwegian research vessel has been assigned the sole task of locating the shoals of herring and keeping the fishing fleet informed by radio of the abundance and distribution of the fish.

In the herring fisheries echo sounders not only assist in the detection of the fish, but also indicate whether the shoals are dense enough to permit economic purse-seine fishing and whether a full length of seine may be used without danger of breaking because of the weight of the fish. The echo sounder is also used to chart shellfish areas and ocean depths, and to study plankton. Recent refinements make it possible to differentiate among species of fish. Today, over four-fifths of all American and British fishing vessels are equipped with echo sounders, which are being used to increase the catch of cod, herring, sardines, anchovies, tuna, and lobsters. Although there is no way to assess quantitatively the increase in catch which can be directly attributed to the use of echo sounders, fishermen have testified repeatedly that the echo sounder has en-

[1] D. P. Norman and W. W. A. Johnson, "Massachusetts Fisheries Industries Today," Dept. of Commerce, Commonwealth of Massachusetts, 1954, p. 10-11.

abled them to find fish where they would not otherwise have found them.

The echo sounder is constantly being improved. The transmission power and impulse rate are being increased; the beam angle, frequency range, and spurious electrical pickup are being reduced. Horizontal as well as vertical echo ranging is now practical. A new scanning device has recently been put into production which will range out at any angle from horizontal to vertical and locate fish or other objects at various depths. These improvements are likely to open a whole new field of commercial fishing in the near future.

A new development in echo finders which has just been introduced from Germany by Radiomarine Corporation is the Fischlupe, or cathode ray depth sounder, specially designed to function as an electronic fish-finder. This instrument begins to bridge the gap between the conventional echo sounder and underwater television. The conventional echo sounder sends out a signal which is reflected back by the first object it meets. The Fischlupe is capable of surveying any selected section of the water from vessel hull to sea bed. When fish intercept the sonic beam, an indication appears on a cathode ray screen, enabling the operator to determine at what depth the fish are swimming. He can secure a magnified trace of an eight-fathom section of water centered on the fish. Accurate measurements of the depth and density of the fish may thus be obtained.

The direct contributions of electronics to the fishing industry continue. Airplanes are used to spot surface schools of menhaden and tuna, and their finds are radioed to fishermen. Ship-to-shore radio-telephones enable fishermen to choose a port where they can obtain the maximum return for their catches. Electronically controlled high-intensity light sources have made possible under water photography of fish, leading to a greater understanding of their habits. Underwater television has been used by a British research vessel on the Grand Banks for the study of redfish and cod. As fishermen go deeper and deeper to catch their fish, it is not at all improbable that blind, and often fruitless, trial tows of the nets will be replaced by the use of underwater electronic devices for the precise location of fish.

German experiments along other lines have shown that dispersed cod and herring can be assembled in front of trawl net openings in the ocean by properly applied electrical currents. In America experiments have demonstrated that it is possible to catch fish without any conventional nets or gear by the use of a suction pump and electric lights.

Despite all these improvements, our commercial fishermen still have to depend on intuition and luck to find good fishing grounds.

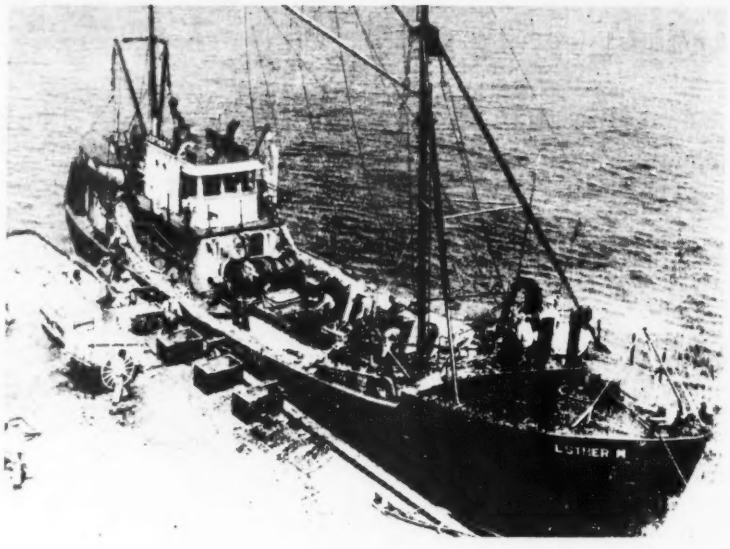


Fig. I. A large modern otter trawler.

We know that lobstermen have for decades been faiii ıg to hunt lobsters on rich grounds because their ancestors accidentally found lobsters elsewhere and never thought to look in unlikely intermediate spots. The echo sounder has revealed many such good lobster grounds. Fish are caught today where few fish were caught fifty years ago, and conversely, few fish are now caught in some of the spots where world record hauls were once made. Many a fishing captain has passed blindly over good fishing grounds to waste time on poor ones, not because he was stupid but because there was nothing to indicate to him there was a sufficient concentration of fish around to warrant setting his nets. Except for the few exploratory trials of marine biological and oceanographic expeditions, there is little attempt made to find new fishing grounds at unusual places.

The fishing industry urgently needs devices for the certain detection of fish, and techniques for the proper use of the devices they already have. No systematic attempt has been made so far to apply the anti-submarine search techniques developed during the war to the location of fish, although the patterns of search are equally applicable. It is obvious also that fishermen trained in the proper search techniques applied to fish, would be equally trained for war emergency work in the anti-submarine and anti-mine work.

Even when the fishermen find fish, their actual fish catching efficiency is low. The trawl nets in use today are almost identical with those used sixty years ago, and underwater photographs have shown that half the fish which enter the nets succeed in swimming out again. The mouth of the nets are held open by massive wooden kites weighing up to 700 lbs. apiece. The combined weight and resistance of the net and kites is such

[2]Daniel P. Norman, "The Impact of Science in the Fishing Industry," *Monthly Review*, Federal Reserve Bank of Boston, December, 1953 and February, 1954.

that on the edge of the Grand Banks, where there are strong currents, even our biggest fishing vessels have to trawl downstream.

In 1948 a New England corporation made a scientific study of the net problem and came up with a process which eliminated nylon's faults while retaining all its virtues. This specially treated and processed nylon is sold under the trade name of Nylock: the other new man-made fibers are similarly processed and treated for use in nets, and are sold under the corresponding trade names of Dalock (for Dacron), Orlock (for Orlon), etc.

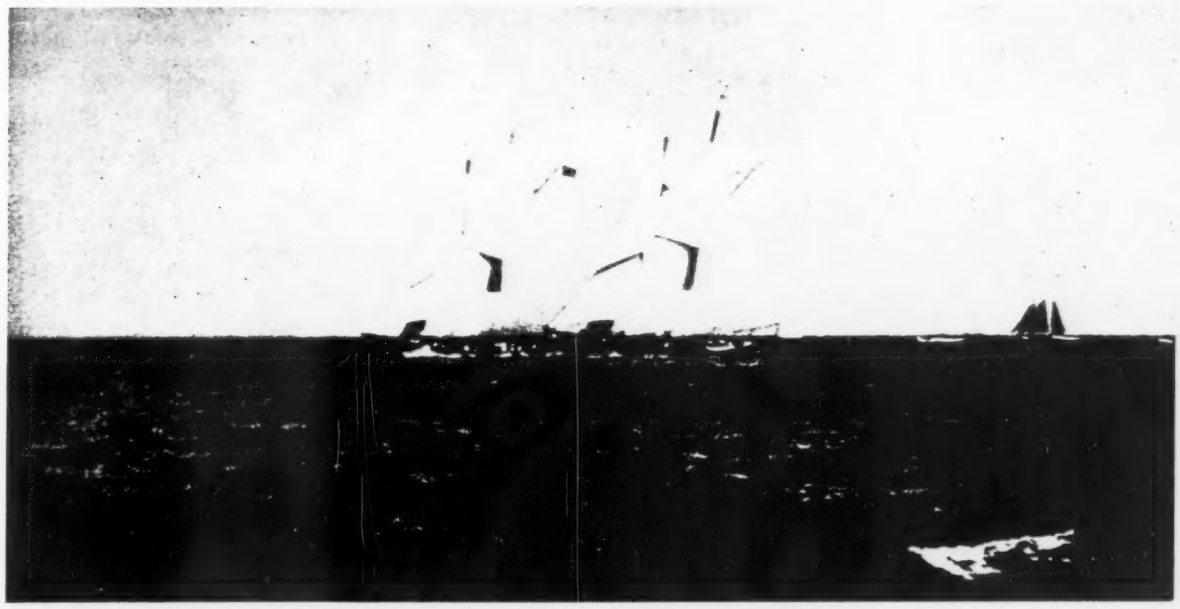
The "lock" process consists of applying a resin to the synthetic fiber, stretching the fiber to the point where its residual stretch or elongation is the optimum required for fishing nets, and setting the resin with heat so that it holds the fiber at the desired stretch. The applied resin coating therefore performs the dual function of providing an anti-slip friction coating which enables the fibers to retain knots, and holding the fibers at the proper tension so that they have just the desired degree of stretch and strength. It also minimizes fraying and prevents the destructive action of iron rust.

Nylock gill nets have many specific advantages over those made from natural fibers. Fishermen have found that they need fewer sets of nets per year, fewer replacements and that the nets are easier to handle and the gear needed is lighter. Yet the number of fish caught per net is greater. One further advantage of the Nylock nets over other nets is that the resin treatment of the nylon fibers smooths and cements down the fuzz on the surface of the fibers, thus leaving less area of surface on which phosphorescent organisms may settle. This is an important feature, because on occasion so much phosphorescence gathers on conventional nets that they appear to be on fire, and the fish avoid them easily. This same absence of fuzz may also account, in part, for the greater number of fish caught in Nylock nets. Apparently many fish can sense fuzzy fibers in time to back water and escape the meshes of the net; in the absence of fuzz, the fish are caught and held by the net before they can retreat.

Nylock is not restricted to use in gill netting. The first complete, all-Nylock, trawl net is now being towed by a small dragger out of Point Judith, Rhode Island. A trawl net is a big bag net towed along the ocean floor and kept open by a pair of nine-foot wooden "kites" or "trawl doors." The weight and water resistance of a complete trawl is so great that a dragger cannot detect the difference in the power requirement of towing an empty net or one full of fish. Nylock is therefore of value not only because of its intrinsically low weight, but because its cross section, and hence water resistance, is much less than that of vegetable fibers of equal strength. The Point Judith dragger, for example, reports that her maximum tow was formerly a 35-foot cotton trawl. She is now successfully towing a 60-foot Nylock trawl, thereby increasing her fish-catching ability.

The tremendous amount of information gathered by the Navy on the use of various types of trawls and paravanes for mine sweepers has not yet been applied in this country to the design and operation of fishing gear, although it is obviously directly applicable. This is a field of applied hydrodynamics in which literally no re-

Fig. II. Last of the Salt-Bankers.



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Hughes Field Engineer H. Heaton Barker (right) discusses operation of fire control system with Royal Canadian Air Force technicians. Avro Canada CF-100 shown at right.

*Scientific and Engineering Staff*

## HUGHES

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*Culver City, Los Angeles County, California*


search is being conducted, although it is urgently needed and would be immediately applied.

It is only when we come to the field of food technology, the processing and preservation of the fish that are caught, that we find our modern technology has lent a major hand. The fishing industry has been responsible in many ways for the development of the entire frozen food industry, including the now familiar pre-cooked food, such as the fishstick. The fund of available information on the problem of frying fish, enzyme degradation of fishery products, and the preservation of fish on the long trip back from the fishing grounds, is still lamentably scarce. In the application of food technology, perhaps the most important future development lies in the conversion of presently unused "trash" fish into attractive edible products.

Most of the new developments in bringing fresh fish to land have been based on the application of refrigeration equipment. Three broadly separate lines of development can be traced: (1) the use of refrigeration equipment to supplement ice, (2) the freezing at sea of only the edible portion of the fish, usually fillets, on factory ships equipped also to convert all the wastes into by-products, and (3) the freezing of whole fish at sea and their subsequent processing on land. All three lines of development are important; the first because it is in commercial use throughout the world, the second because it is helping solve the European fresh fish problem, and the third because it promises to afford a practical solution to many of the problems of New England's deep-sea fishing industry.

Less than twenty-five years have elapsed since it was discovered that the then worthless redfish yielded excellent fillets which could be sold throughout the country as "ocean perch." Well over ten millions dollars' worth of ocean perch fillets are now produced annually on the East Coast. There are many other fish which are now thrown back into the sea or are sold for fertilizer which can be made into valuable food products.

The Food and Agricultural Organization of the U.N. has been carrying out successful large-scale experiments in South America in the use of fish flour in bread as a protein supplement in protein-poor countries; plankton products are a commercial item of sale in Thailand. In this rich country of ours, we turn up our collective noses at anything that is not familiar, even though we are conscious that it may be good. Clams are in great demand, especially when fried, but we have no established market for mussels, although in Europe they are considered superior to clams. I can certify personally that mussels are wonderful eating, and a fresh mussel from our own beaches is far superior to a clam imported from Canada, but short of a million-dollar advertising campaign, there is no way to convince the buying public of this fact.

Similarly, look at fishsticks. Fishsticks are made by piling cod or haddock fillets in neat blocks, freezing the block, and then sawing it with band or circular saws into neat rectangles. The natural juices in the fish act as an efficient binder, so that the original individual layer of fish fillets are firmly bound together. So far, only cod and haddock have been found to make dependably good fishsticks. Other fish are either too oily, or don't adhere together properly in stick form, or lose their flavor. Our fishermen catch relatively little cod and haddock, so our fish processing plants are humming with activity based on imported fish, to the profit of the shore workers and the distress of the fishermen. We urgently need; a) the technical information on how to convert the lowly whiting and similar fish into edible products of familiar shape, and b) a means of inducing the public to buy the many unfamiliar but nutritious and delectable sea products for which there is now no market.

Of necessity I have touched only very briefly on a subject of tremendous importance to us all, and to our Coastal regions in particular. Our last untapped natural resource is the ocean, and so far our generation has made only trivial progress in exploiting it. In other countries a concerted attempt is being made to win food from the sea: the Scotch have just launched the world's biggest trawler, the revolutionary Fairtry, and sent it to the Grand Banks to compete with our old-style smaller vessels; the Scandinavians have sent a completely equipped floating electronic laboratory to sea with their fishing fleets to help them to locate and catch fish; the Russians have been pioneers in the use of factory ships, which process fish at sea, and have just purchased two more; the Greeks, the Japanese, and many other nations are actively at work with new gear, new boats, and new outlooks on the problem. If we are not to see ourselves hopelessly outdistanced in the race for food, if we are to continue to have the world's highest standard of nutrition, it is imperative that we become more familiar with the ocean's resources and devote more of our scientific abilities and know-how to the problem of the profitable exploitation of the sea.


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# the mineral industry of south america

Herbert S. Jacobsen

Limited knowledge about the existence and magnitude of many mineral deposits in Central America is paralleled by a rather small mineral industry. The primary cause of this situation is the physical character of the region itself. Central America is a relatively narrow ribbon of tropical land about one thousand miles long. Most of this region is covered by dense tropical vegetation.

## THE JUNGLE; AN ECONOMIC BARRIER

The prolific jungle growth is the chief barrier against the economic development of the region. It particularly hampers the development of mineral resources. The jungle does this by making the building and maintenance of transportation facilities both difficult and costly. Consequently, present transportation facilities in Central America are meager. Many localities depend on airplanes or mules, since there are few roads and fewer railroads. Most roads, that do exist, are poor. They are often impassable during the rainy season, which lasts several months. This lack of adequate transportation facilities, often makes the development of a mineral deposit impractical.

Besides preventing access to the mineral wealth, the jungle frequently hinders its discovery. Geological exploration is difficult in most areas and almost impossible in others. Few parts of Central America have been thoroughly studied by geologists, while some portions have not been explored at all. Yet, despite the difficulties imposed by the tropical environment many mineral deposits have been found and exploited.

## PRESENT INDUSTRY

### *Gold; a Major Product*

The present mineral industry in Central America is small but thriving. The industry is aided by cheap labor and low taxes. It is also helped by the fact that its chief product, gold, can easily be transported.

Gold is produced by most countries in Central America. The exceptions are: British Honduras, (which has no mineral industry at all), and Guatemala, (which produces only insignificant amounts of gold). Despite the large number of gold deposits in the region, the total amount of gold produced in Central America is comparatively small. Central America only contributes 0.37% of the world's annual gold production. The magnitude and distribution of gold production in Central America is as follows:

| Country | Ounces of Gold Metal Produced (1949) |
|---|---|
| Nicaragua | 200,000* |
| Honduras | 25,832 |
| El Salvador | 25,000* |
| Panama | 9,657 |
| Costa Rica | 1,096 |
| Guatemala | 5 |
| Total | 261,590 |

* Estimated amount.

### *Products Other Than Gold*

The mineral industry of Central America, exclusive of the gold mining industry and the silver production associated with it, is very small. Perhaps the only exception is an entirely new lead and zinc mining operation recently built by American capital in central Guatemala.

Besides this large lead and zinc mine, a small lead and zinc mine has been producing in Guatemala for many years. Another small mining operation is a chromite mine in Guatemala. It produces about 600 tons of ore annually, which contains approximately 200 tons of chromium. A third small mining operation in Guatemala is an iron mine producing 1,800 tons of ore per year for domestic consumption.

During the First World War substantial amounts of manganese were mined on the Nicoya Peninsula in northwestern Costa Rica. This production declined sharply after the war ended as shown here:

| Year | 1916 | 1917 | 1918 | 1921 | 1938 |
|---|---|---|---|---|---|
| Tons of Manganese Produced | 1,244 | 7,163 | 9,968 | 3,202 | 300 |

The reason for this decline was, of course, that manganese became available from other cheaper sources.

In addition to the above-mentioned products, Central America produces minute amounts of a number of minerals. Antimony is mined at the rate of about eight tons a year in Honduras. Mica has been produced at various times in several Central American countries. For example, Guatemala produced ten tons in 1926. Furthermore, small amounts of saltpeter and sulfur are produced by the Guatemalan natives for use in their fireworks.

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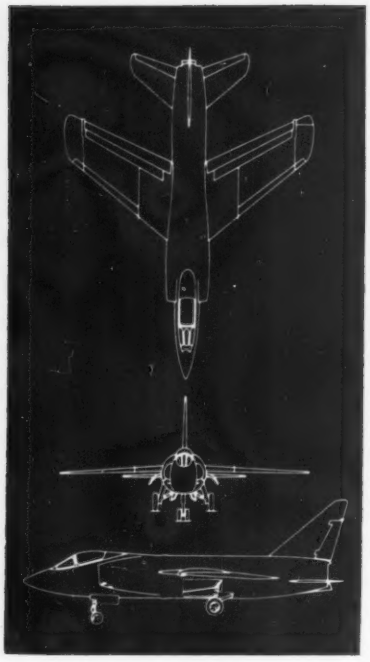

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## FUTURE INDUSTRY

As may be seen from the foregoing summary of Central American mineral industries the sum total of the region's mineral production is rather small. The future expansion of this industry is dependent on many factors, but most important is the magnitude of the demand for the mineral resources of the region.

*Expansion of Present Industry*

Most mineral deposits now being mined in Central America will probably continue to produce for many years either at present rates of production or with increased output. One exception is the Agua Fria gold mine which will become depleted in the near future. On the other hand, the gold industry as a whole may expand considerably. This would result if the mining of river beds by individual natives were replaced by dredging. A particularly good dredging prospect is the gold belt in Costa Rica.

In addition to gold, lead and zinc production will almost certainly expand due to the worldwide shortage of these metals. On the contrary, most of the other existing mineral producers in Central America are not likely to increase their production. This is chiefly due to the small size of the mineral deposits.

Much better potentialities for the expansion of the Central American mineral industry lie in deposits that have not yet been exploited. These sources of mineral wealth may be classified into two groups:

1. Mineral deposits that have not been discovered up to now.
2. Mineral deposits that are known to exist but have never been exploited.

*Exploitation of Undiscovered Deposits*

The existence of undiscovered mineral deposits, is sometimes regarded as somewhat hypothetical. Nevertheless, it seems safe to assume that these deposits exist, since many portions of Central America have not been adequately explored. Finding the deposits may be difficult because of the tropical terrain. However, new exploration methods may well lead to new sources of mineral wealth. Among the new exploration methods are aerial magnetometer surveys and geochemical prospecting methods. The aerial magnetometer is useful in finding ores of magnetic materials such as iron, titanium, and associated metals. Geochemical methods help in discovering heavy metals like copper, lead, or zinc by testing the heavy metal content of streams and soils.

Both means of exploration would be particularly applicable in Central America, where rocks are generally covered and indirect methods must be used to find ore.

*Exploitation of Known Deposits*

A more concrete basis for the expansion of the Central American mineral industry, than the undiscovered deposits, are those mineral deposits that are presently known but unexploited. These deposits are sources of about a dozen different mineral products.

Probably the most promising sources for future exploitation are those of iron. One promising source is the Agalteca mountain in central Honduras. It is literally a mountain of iron ore. According to a conservative estimate it contains 25 to 30 million tons of ore with an iron content of over 60%. The ore also contains a small amount of manganese. The chief obstacle impeding the exploitation of this rich iron deposit is its inaccessibility. It lies 200 miles from the sea and about 100 miles from Honduras' single existing railroad line. Consequently, a railroad must be built before the Agalteca mountain can achieve economic value.

Another iron deposit, not presenting this transportation problem, is found in the beach sands of the Gulf of Nicoya in Costa Rica. No accurate details are known about the size or grade of this deposit but it is not likely to be of great economic value because of its silicon content. Other smaller iron ore deposits exist in Guatemala and in El Salvador, but their economic potentialities are unknown. In addition, a large belt of Ilmenite ore exists in Nicaragua. At present there is no demand for this ore, but in the future it may become valuable as a result of its Titanium content.

Like iron, copper is found in several deposits in Central America. One relatively small economically valuable deposit lies on the Bambano River near Nicaragua's east coast. This deposit was mined for a few years but now lies untouched.

Also manganese exists in several deposits in this region. The most promising of these, are two manganese deposits near the northern coast of Panama close to the Panama Canal. The two deposits are not far from each other and together contain at least 15,000 tons of approximately 55% manganese ore. The manganese tonnage may prove to be much larger when the size of the deposit is better known.

Large amounts of manganese ore are also found in Costa Rica, particularly on the Nicoya Peninsula. The ore in this area was mined during World War I, (as mentioned earlier), but much ore still remains. While a sizeable portion of the high grade ore has been removed much of it is still available. The disadvantage of this manganese source is that the ore is spread over a large area and is therefore expensive to mine.

Central America's silver resources are much smaller than those of manganese. There is only one known silver deposit in addition to the silver associated with several gold deposits. The lone silver deposit is in northwestern Nicaragua and was mined at one time. Further mining awaits a greater demand for silver.

In contrast with some of Central America's metallic resources, petroleum may have a promising future. Much oil exploration work has been done throughout most of the region in recent years. Also several wells have been and are being drilled without striking oil. However, there still is strong evidence for the existence of oil. For instance, oil seepages have been detected at two locations in Honduras, and at many points along the Pacific coast of Costa Rica and Panama. Also, asphalt seepage has been detected near Mosquito Gulf on the northern coast of Panama. Furthermore, a number of structural traps that may contain petroleum are known. The most promising oil structures are located in northern Guatemala and adjacent areas of British Honduras. All the known evidence indicates that possible petroleum resources exist in every Central American country except El Salvador. However, any oil basins that do exist, particularly in Honduras and in Nicaragua, are likely to be of limited extent because of the large number of magmatic intrusions in the area. Also extensive faulting, especially in Honduras, would limit the size of a possible oil pool. Development of petroleum resources is hampered by transportation difficulties and by disadvantageous Petroleum Laws in some countries.

*General Future Prospects*

Despite the existence of some valuable untapped deposits in Central America it is not likely that its mineral industry will undergo any substantial expansion in the foreseeable future. The high grade manganese and iron deposits are promising prospects for enlarging the region's mineral industry, but this is not likely to happen until the demand for these metals becomes sufficient to overcome the difficulties the terrain imposes on their exploitation. On the other hand, some new mineral deposits may be discovered which have sufficient economic value to warrant their exploitation and the consequent growth of Central America's mineral industry.

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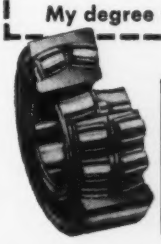

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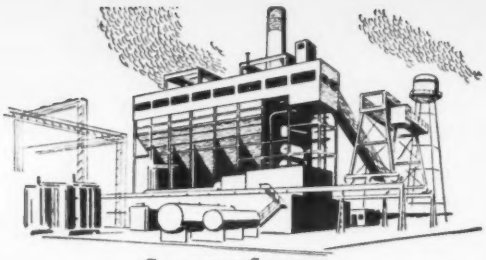

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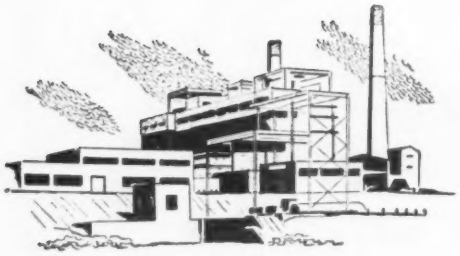

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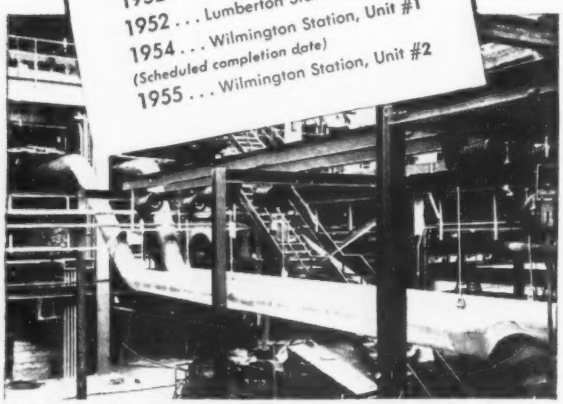

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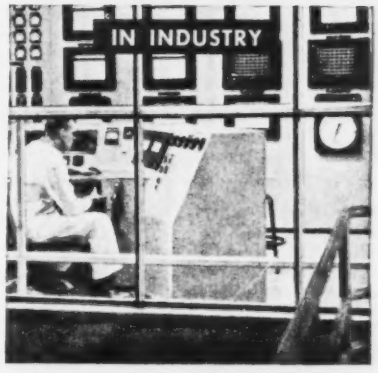

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# a positivistic approach

Barry Mazur

This is written as sort of a sequel to: "On the Limitations of Mathematical Reasoning" which appeared in the November issue of TEN. I greatly appreciate the response given to it. There were, of course, many who disagreed with my basic presuppositions, and I am indebted to them for some lively discussions which were centered about the views presented in that article. In consideration of the fact that the treatment of "On the Limitations of Reasoning" was in the main, negative, I should like to closely follow it up with a more affirmative, and positivistic approach to the question: How invincible can mathematical reasoning be made?

The main loophole in the irrefutability of a mathematical proof, we decided, was incompatibility. Whatever is done, it appears, one can never erase all possibility of one's presuppositions being in mutual agreement. We can't be too sure that they are compatible. I shall attempt to present a view of the structure of mathematical systems in such a manner that one may perhaps see the relationship between that bugbear, incompatibility, and the system itself. It shall also serve as the groundwork for constructing proofs for the compatibility of certain geometries. (If that sounds as if it is in direct antithesis to the conclusion of the previous article, it is only so on the surface, for those proofs themselves must depend upon the contingency of the mathematical system which I shall presently erect.) In effect the invincibilities of mathematical systems can be related to one system such that if the system is compatible, then the rest are. There must be some starting point. The one that I choose to use is completely algebraic. Any logical system shall be considered as included in my treatment.

The analogy shall be drawn between a logical system and a vector space. The analogy, I believe, will be drawn so closely, that existing theorems in abstract vector algebra will become directly applicable to the "Logic Algebra" which I shall present. Some elementary terminology will be taken for granted but for the most part, all terminology used in peculiar senses will be defined throughout the course of the presentation.

Definition: A propositional element is an element constructed such that corresponding to each there exists an element not-E, where E is the propositional element.

Definition: The element corresponding to E, or not-E, shall be called the "cognate" of E.

Definition: E is equal to not-not-E.

Definition: A propositional space is a set of propositional elements such that under some set of transformations, B, it is automorphic.

Definition: A propositional subspace S of a space V is a subset of V which is itself a Propositional space.

As we go along, it can readily be seen that we look at logic in somewhat similar terms as we view vector space. Indeed, by merely rearranging nomenclature it follows the algebraic system pretty much. Where algebra speaks of addition and multiplication, we speak of transformation, which is a broader term. What is meant by it is any operation that is done to some proposition in a logical structure to deduce a second proposition. It may be a binary operation. In other words, it may employ some other proposition to arrive at the transformation. For instance, the ordinary syllogism is merely a binary transformation: A+B=C, or in particular, given the major premise, A and the minor premise, B, we arrive at the conclusion C. A transformation could possibly be the operation of adding equals to equals in algebraic equations. In any formal proof, to get from one step to the next, or from one equation to the next, a transformation of one sort or another must be employed. Hence it appears as if any theorem in any postulate system is merely one proposition of that system which has undergone a number of transformations. Actually I shall define a theorem as exactly that, but there is an even more important concept to deal with first, that is independence.

In Vector Algebra, two or more vectors are independent if no vector can be expressed as some linear combination of the others. I shall define it analogously.

Definition: The elements, $\epsilon_1, \ldots \epsilon_n$, in a space V are dependent if and only if some one of the elements, Ei, is a transformation, or series of transformations of the other elements. Elements which are not dependent are called independent.

Dependence in a logical system has great importance, as we may begin to see later.

Definition: The generating elements, or generators of a propositional space are those elements that can produce all elements of the space under the set of transformations $\beta$. They are said to generate, or span the propositional space. Henceforth the set of generators of a space shall be called a doctrine.

Definition: A theorem H of a doctrine D is a propositional element generated by the transformations on elements of the doctrine.

Theorem: The set of all theorems of any doctrine in a space V is a subspace of V.

It follows as a trivial consequence of the definitions previously stated, and, of course, an analogous theorem holds in abstract vector algebra as well. I could run down quite a number of interesting theorems that can be developed by the definitions stated above, however, the purpose of this article is not to deliver an exhaustive development of this Logic Algebra, but merely to present it as a method of viewing all possible systems which we term logical systems. It requires no generalizations and includes as special applications any form of rational construction, for the terminology, propositional element, and transformation can be made to include almost anything. The transformation I, or the identity transformation is that which leaves the proposition as it found it. One may consider each transformation on the space as a "permutation group" on it.

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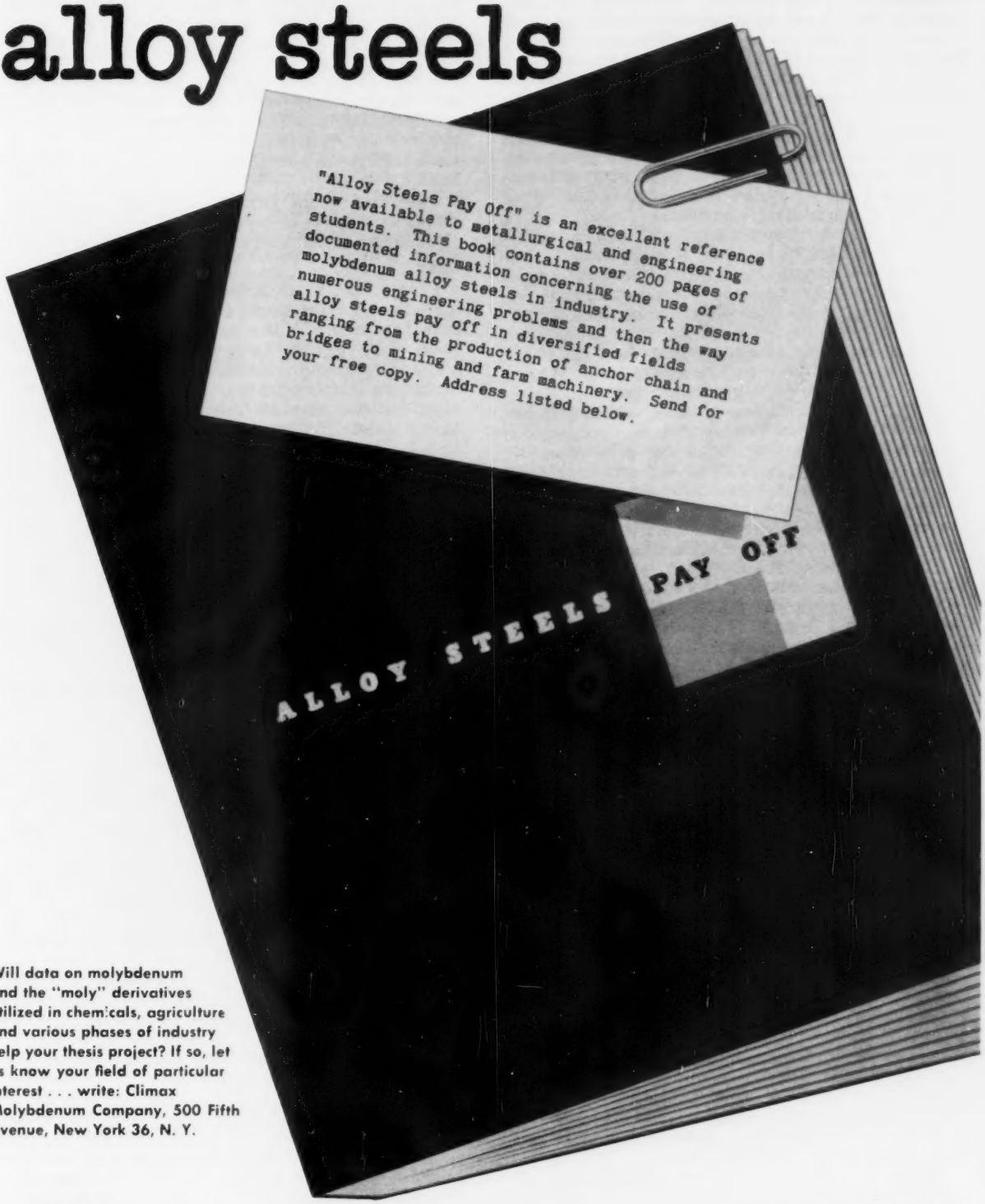
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Definition: The space V composed of the cognates of the elements of the space V is called the co-space of V.

We are now ready to define what is meant by compatibility:

Definition: A set of independent propositional elements are said to be compatible under transformation B, if and only if $T \frown T = \phi$ or, in other words, if it is a null class, where T is the space generated by the propositions.

Theorem 2: A doctrine D, such that $T \frown T^1$ is not a null class (where $T \frown T^1$ is the space generated by D), can be broken up into two proper subsets where one subset is the co-set (or is composed entirely of cognates) of the other.

Proof: Every generator $G \in (T \frown T^{-1})$ implies that $G \in T$ and $G \in T^{-1}$. However if $G \in T$, then $G^{-1} \in T^{-1}$ and if $G \in T^{-1}$ then $G^{-1} \in T$ (by the definition of $T^{-1}$) and hence $G^{-1} \in (T \frown T^1)$. That means that for every generator $G \in (T \frown T^1)$ there is another one, $G^{-1} \in (T \frown T^{-1})$. q.e.d.

Definition: The elements of a doctrine, such that $T \frown T^{-1}$ is not a null class, are called incompatible (where T is the generated space).

Definition: A doctrine whose elements are incompatible, is called inconsistent.

Relevancy: Since our definitions allow propositions of such latitude to enter our systems, there must be some term to describe whether or not those propositions mean anything together or not. This we shall call relevancy. To illustrate this, we may construct a system of logic, or a propositional space composed of the following propositions under the transformation of the syllogism: (1) Two (2) John loves Marsha (3) Socrates is a man[1] (4) All men have lollipops.

In the first place, all four elements are propositions, if we assume that there exist propositions: ($1^1$) Not two ($2^1$) John does not love Marsha ($3^1$) Socrates isn't a man ($4^1$) Not all men have lollipops, since we make no restrictions on the acceptance of propositions other than that. It is obvious that our choice of propositions is to all intent and purposes absolutely unrestricted. It can of course also contain noise, or unmeaningful statements, (as indeed many otherwise logical doctrines do), or even silence.

Let us examine what theorems may be deduced from those four generators. Well, by the syllogism transformation, we may deduce that: (a) Socrates has a lollipop. Unfortunately that is about all. The reason that we cannot include propositions (1) and (2) in any syllogistic transformation is that they pertain to two subjects that are entirely removed from the other propositions, or, in a word, they are irrelevant.

Definition: If a propositional space can be broken into two proper complementary subspaces, then, the sets of elements generating each subspace are said to be mutually irrelevant. If the space cannot be broken into such subspaces, then and only then are the set of elements comprising the doctrine of the space mutually relevant.

Definition: A doctrine whose elements are mutually relevant is called a contiguous doctrine. If they aren't, it is called an incontiguous doctrine.

The three relatively important aspects of logical geometries and logic systems in general have been defined in terms of algebraic concepts. The question now arises: how sturdy is this approach, since it is begun on a dangerously high level where there is a serious possibility of the roots of the system being incompatible? Fortunately Vector Algebra enjoys a peculiarly sturdy position in mathematics because its basis, the framework of terms which I didn't bother to define, is built up entirely of definitions.

We shall be in a position later to prove that such systems are compatible (under the usual transformations). That, of course, doesn't prove this system consistent, for if it weren't consistent, then any proof that it could present would not hold.

Definition: The number of propositional elements in a space is called the order of the space.

Theorem 3: All spaces of order one are consistent.

Proof: For, by definition, if it weren't consistent, then $V \frown V^{-1}$ would not be a null class. However, the order of V is equal to or greater than the order of $V \frown V^{-1}$, and by theorem 2: if $V \frown V$ is not a null class, then the doctrine generating it can be broken up into two proper subsets. But the generating doctrine must be of order 1 or less, in which case it cannot be broken up into two proper subsets, hence $V \frown V^{-1}$ must be a null class.

Corrolary: Any doctrine, all of whose elements are mutually independent, that has the same order as its generated space, is consistent.

Corrolary: The generators of all such spaces are all mutually irrelevant.

In the above theorems, I have assumed a number of trivial consequences of the definitions for the simple reason, again, that it is beyond the intentions of this article to delve into the expansion of this at too great length.

In order to deal with these concepts in a more restricted sense, or for applications to usual geometries, we shall have to define a more limited form of proposition. We shall make use of the fact that all propositions in geometries as we know them deal with the relationships between terms; certain of these terms have been defined beforehand, certain of them have not. With exceeding fear and caution I shall begin to define: defined term, definition postulate, and many other things which are used in such systems. Curiously enough, I shall leave the term, undefined term, undefined.

Definition: A functional proposition is one that relates one **term** to others.

Explanation 1: A definition is a functional prop which introduces a **new** term and relates it to previously introduced terms and undefined terms.

Definition: A defined term is that which has been introduced by a definition.

Definition: A postulate is a functional proposition that does not introduce a new term.

It can be seen that all postulates could be considered as definitions and vice versa depending upon the order in which they appear in a geometry. The same is true of **some** undefined terms, (they could possibly be considered defined terms if the wording were rearranged somewhat).

Definition: The **degree of freedom** of a space is

the number of undefined terms employed in the doctrine.

Definition: The **degree of limitation** of a space is the number of postulates employed in the doctrine.

Those definitions serve to allow us to examine the necessities for consistency in ordinary spaces. We denote our definitions as: AiR(Ai-1,Ai-2), where Ai is the term introduced, and Ai-1, . . . A1 are the previously defined terms; the i'A are the undefined terms, and R is the relationship between Ai and all the rest. The transformation that we shall consider is replacement of equals with their related equals. Mathematically: Given two propositional functions a=f(b), and b=f(c), the binary transformation a=f(F(c)) is permissible. Well, that is a transformation that we are accustomed to, and the space, as I've restricted it, makes propositions in it to look like equations of some sort, where each term is a variable.

Definition: The *rank* of a space is the number of definitions in the space.

Corrolary: The number of defined terms in a system is equal to the rank of the space.

Each space can be now thought of as a number of relations (or equations) in a number of variables. I shall not prove this, but it should seem quite reasonable that a doctrine generating a space consisting only of *definitions* is always consistent. For if Q is the rank of the space, and f is the degree of freedom, purely algebraic considerations allow us to look upon the doctrine as Q independent equations in Q+f unknowns. It can *clearly* be proven that such a doctrine is a blank matrix with exactly f degrees of freedom for the variables. Such a matrix can never produce contradictory results so long as each equation introduces another variable. This makes feasible the theorem that I shan't rigorously prove:

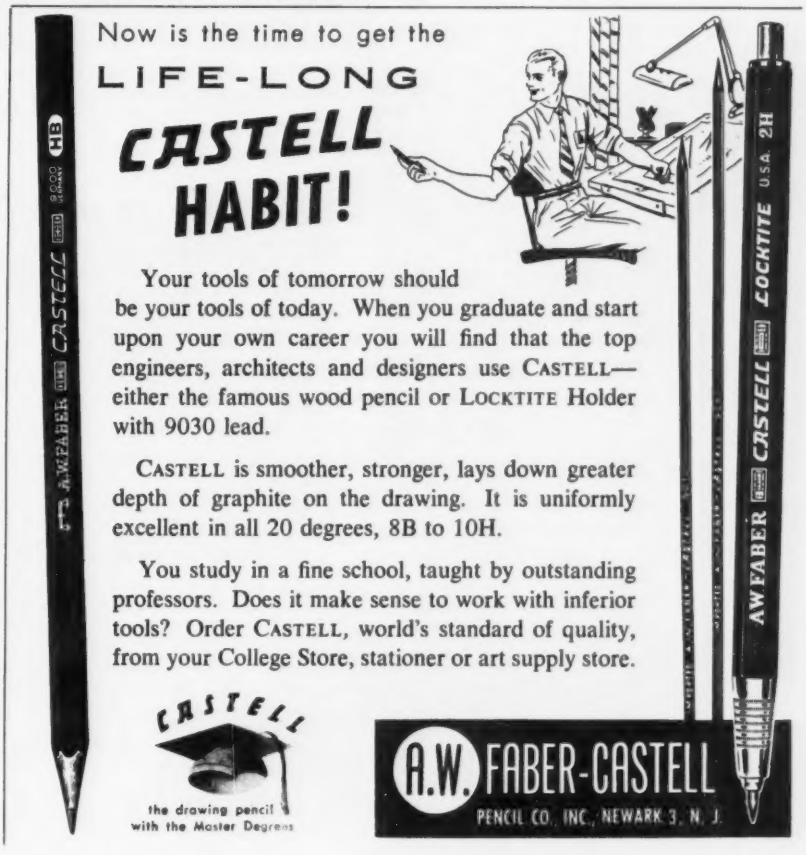
Theorem 4: All doctrines composed entirely of definitions and under the "substitution" transformation, are always consistent.

A little reflection on this will verify the fact that many doctrines that contain postulates can be reworded such that those postulates are merely "definitions of the undefined terms." If a doctrine can be reworded in that manner, with a couple of undefined terms left over, then that, too, must be consistent. Euclid's geometry can be reworded in that manner, and I am relieved to confirm its consistency.

The reader can see, I believe, that there exist many possibilities for the expansion of this angle of attack. Many beautiful theorems can possibly be constructed about these general logic systems, and quite a few doctrines can be rigorously proven to be consistent, using this approach as a standard, although I did not go through it in this article. I'm sure that quite a few unorthodox "logical" systems can be constructed and examined, as special cases of the concepts defined above. It should be carefully noted that nowhere was there mention of truth or falsity in my approach. I believe that possibly greater latitude can be gained if we ignore those concepts as being unnecessary for the formation of Logic.

The attempt in this article has been to look at the framework of all semantic and mathematical constructions in a new light so as to be able to analyze their limitations, their actual make-up, and fundamental properties. The method presented by the author is believed to possess enough generality so that those systems may be analyzed for their, so to speak, intrinsic properties rather than for special consequences that are applicable to a limited number. What exactly can we **not** expect from any semantic grouping of propositions? Must they conform to some ultimate truth or falsity? Or are there other possibilities as many-valued logicians assert? It is confessed that the author is anything but an authority on the subject of many-valued logic, but I submit the possibility that this system may have some interest to those who are familiar with that subject.

At any rate one definite outgrowth of it is a method of proving compatibility. Since the views presented in this article are quite new, (as far as I know), any criticism of it, or suggestions for the improvement of it will be welcomed by the author. If anyone has any development of the ideas presented here, he is requested to notify the author about it.*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**ONE PAINT IN A HUNDRED**—Toronto's new $50,000,000 subway is modern in every way, including its glistening tile walls and brightly painted ceilings. For the ceiling, a paint was needed that could resist high humidity. More than 100 were tested and a paint based on Hercules Parlon® (chlorinated rubber) selected. On all types of surfaces, interior and exterior, Parlon paints are providing outstanding service at lower long-term cost.

**FOR A WHITE HOT RECIPE**—Pouring molten metal to produce castings weighing 30 tons or more places a heavy demand on the sand. Molds and cores for steel and cores for iron "stay put" when bonded with Truline® binder. Yet cores are easily removed when metal has set. And Truline means cores can be baked in half the normal time, preventing foundry oven bottlenecks; reducing man hours per ton.

HERCULES

*HERCULES POWDER COMPANY*
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054-11

# "Allis-Chalmers Graduate Training Course Gave me a head start"

**says GERALD SMART**

*Marquette University, BS—1948*
*and now Supervisor of Plant Engineering,*
*Allis-Chalmers, Norwood, Ohio, Works*

"MOST MEN graduating from college don't have a clear idea of what they want to do. These individuals are helped by Allis-Chalmers Graduate Training Course to find the right job whether it be in design, sales, engineering, research or manufacturing.

"My case is a little different, however. I started the course with all my interest centered on tool design and 'in-plant' service. The reason is that I started getting vocational guidance from some very helpful Allis-Chalmers men back in 1940."

### Served Apprenticeship

"At their suggestion I had gone to school part time while working full time. This not only gave me the chance to serve an apprenticeship as a tool and die maker, and earn money, but I learned what I wanted to do after graduation.

"Then came the war and service in the Navy. After the war I finished school. By the time I started on the course in 1948, I knew what I liked and seemed best fitted to do. As a result, my entire time as a GTC student was spent in the shops.

"The 18 months spent in the foundry, erection floor and machine shop have all proved valuable background for my present job.

"As supervisor of plant engineering at the Norwood Works, I am concerned with such problems as: Plant layout, material handling equipment and methods, new construction, new production methods to be used in building motors, centrifugal pumps, and *Texrope* drives. It's an extremely interesting job.

"From my experience, I'd say, whether you're a freshman or a senior it will pay you to talk to an Allis-Chalmers representative now. You can't start planning your future too soon. And you can't plan starting at a better place, because Allis-Chalmers builds so many different products that you'll find any type of engineering activity you could possibly want right here."

### Facts You Should Know About the ALLIS-CHALMERS Graduate Training Course

**1.** It's well established, having been started in 1904. A large percentage of the management group are graduates of the course.

**2.** The course offers a maximum of 24 months' training. Length and type of training is individually planned.

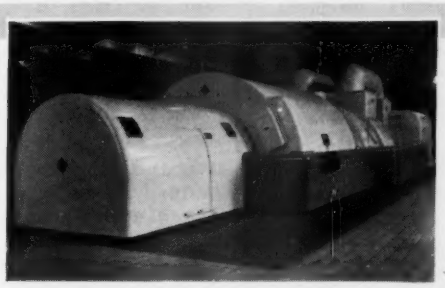
**3.** The graduate engineer may choose the kind of work he wants to do: design, engineering, research, production, sales, erection, service, etc.

**4.** He may choose the kind of power, processing, specialized equipment or industrial apparatus with which he will work, such as: steam or hydraulic, turbogenerators, circuit breakers, unit substations, transformers, motors, control pumps, kilns, coolers, rod and ball mills, crushers, vibrating screens, rectifiers, induction and dielectric heaters, grain mills, sifters, etc.

**5.** He will have individual attention and guidance of experienced, helpful superiors in working out his training program.

**6.** The program has as its objective the right job for the right man. As he gets experience in different training locations he can alter his course of training to match changing interests.

For information watch for the Allis-Chalmers representative visiting your campus, or call an Allis-Chalmers district office, or write Graduate Training Section, Allis-Chalmers, Milwaukee 1, Wisc.



**Steam turbines,** condensers, transformers, switchgear, regulators are built for electric power industry.

**Motors, control,** *Texrope* V-belt drives—all by Allis-Chalmers are used throughout industry.

# ALLIS-CHALMERS

C-5678

*Texrope* is an Allis-Chalmers trademark.

# turbo encabulator

*Editor's Note: For nearly twenty years the "Industrial Bulletin" of Arthur D. Little, Inc. has endeavored to interpret scientific information in terms that the layman could understand. The present contribution is, however, of such basic significance to scientific thought as well as to industrial progress, that the company thought it best to print it without delay for the benefit of those specialists who could fully appreciate its precise terminology. Perhaps one of these specialists will later offer a more general interpretation.*

*In this same spirit of scientific expediency we here reprint the original paper exactly as it was first presented. We regret that, despite the relaxation of wartime security regulations with their attendant hazards, the authors of this paper have preferred to remain anonymous.*

For a number of years now work has been proceeding in order to bring perfection to the crudely conceived idea of a machine that would not only supply inverse reactive current for use in unilateral phase detractors, but would not only supply inverse reactive current for use in unilateral phase detractors, but would also be capable of automatically synchronizing cardinal grammeters. Such a machine is the "Turbo-Encabulator." Basically, the only new principle involved is that instead of power being generated by the relaxive motion of conductors and fluxes, it is produced by the modial interaction of magneto-reluctance and capacitive directance.

The original machine had a base-plate of prefabulated amulite, surmounted by a malleable amulite, surmounted by a malleable logarithmic casing in such a way that the two spurving bearings were in a direct line with the pentametric fan. The latter consisted simply of six hydrocoptic marzelvanes, so fitted to the ambifacient lunar waneshaft that side fumbling was effectively prevented. The main winding was of the normal lotus-o-delta type placed in panendermic semiboloid slots in the stator, every seventh conductor being connected by a non-reversible tremie pipe to the differential girdlespring on the "up" end of the grammeters.

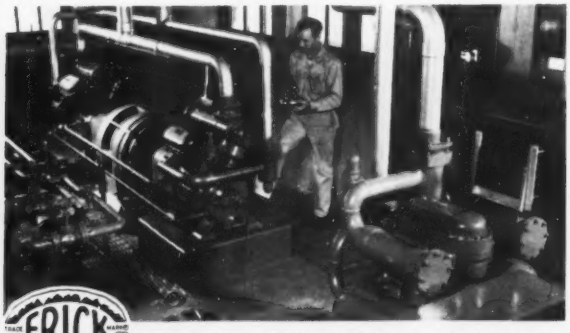
Forty-one manestically spaced grouting brushes were arranged to feed into the rotor slip-stream a mixture of high S-valve phenyhydrobenzamine and five per cent reminative tetryliodohexamine and five per cent reminative tetryliodohexamine. Both of these liquids have specific pericosities given by P-2.5C where n is the diathetical evolute of retrograde temperature phase disposition and C is Cholmondeley's annual grillage co-efficient. Initially, n was measured with the aid of a metapolar refractive pilfrometer (for a description of this ingenious instrument, see L. E. Rumpelverstein in "Zeitschrit fur Elektrotechnistiatischs-Donnerblitze," vol. vii.), but up to the present date nothing has been found to equal the transcendental hopper dadoscope. (see "Prological Sciences," June, 1914.)

Electrical engineers will appreciate the difficulty of nubing together a regurgitative purwell and a supramitive wennelsproket. Indeed, this proved to be a stumbling block to further development until, in 1942, it was found that the use of anhydrous nangling pins enabled a kyptonastic bolling shim to be tankered.

The early attempts to construct a sufficiently robust spiral decommutator failed largely because of a lack of appreciation of the large quas-piestic stresses in the gremlin studs; the latter were specially designed to hold the roffit bars to the spamshaft. When, however, it was discovered that wending could be prevented by a simple addition to the living sockets almost perfect running was secured.

The operating point is maintained as near as possible to the h. f. rem peak by constantly fromaging the bitumogenous spandrels. This is a distinct advance on the standard nivelsheave in that no dramcock oil is required after the phase detractors have remissed.

Undoubtedly, the turbo-encabulator has now reached a very high level of technical development. It has been successfully used for operating nofer trunnions. In addition, whenever a barescent skor motion is required, it may be employed in conjunction with a drawn reciprocating dingle arm to reduce sinusoidal depleneration.

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For testing aircraft at speeds up to 5,000 m.p.h., the National Advisory Committee for Aeronautics operates several large wind tunnels at Ames Aeronautical Laboratory near San Francisco.

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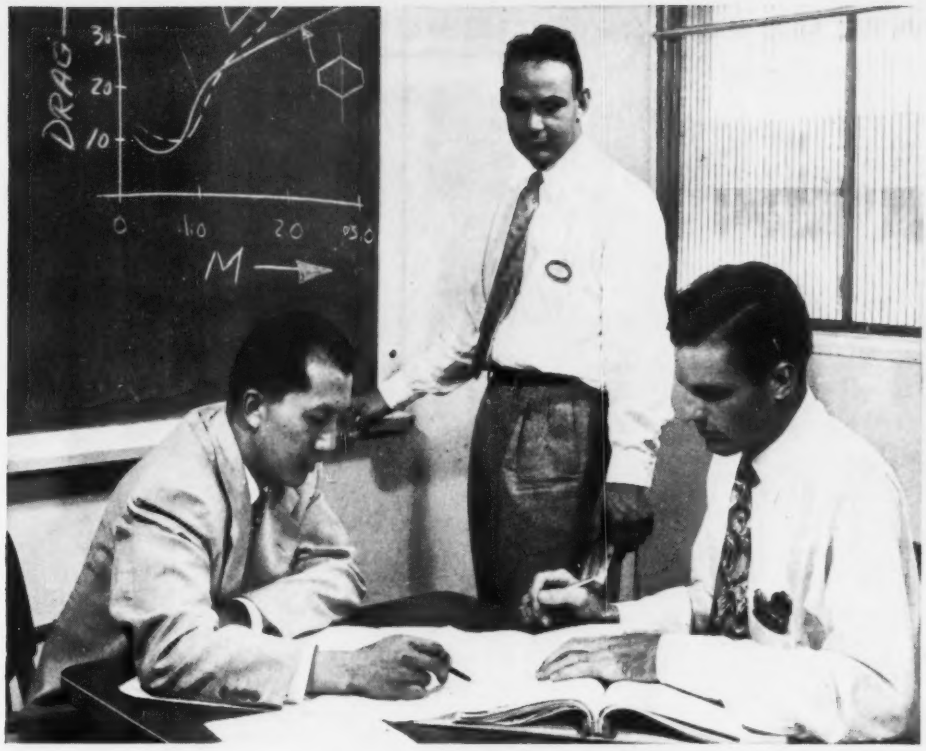


**Jim Hong,** *Aerodynamics Division head, discusses results of high-speed wind tunnel research on drag of straight and delta wing plan forms with Richard Heppe, Aerodynamics Department head (standing), and Aerodynamicist Ronald Richmond (seated right).*

# Lockheed Expands Aerodynamics Staff

**With five prototypes already in or near flight test,** Lockheed's Aerodynamics Division is expanding its staff to handle greatly increased research and development on future aircraft in commercial and military fields.

The five prototypes, which show the breadth and versatility of Lockheed engineering, are: The F-104 supersonic superiority fighter; XFV-1 vertical rising fighter; C-130 U.S.A.F. turbo-prop cargo transport; R7V-2 U.S.N. turbo-prop Super Constellation transport; and an advanced jet trainer of the T-33 type.

**New projects now in motion are even more diversified** and offer career-minded Aerodynamics Engineers and Aerodynamicists unusual opportunity to: Create supersonic inlet designs for flight at extremely high altitude; match human pilots with rapid oscillations of supersonic aircraft at low altitude; develop boundary layer control systems for safe take-off and landing of fighters and transports; remove aileron reversal and tail flutter problems incurred in high speed flight through analysis and design; participate in determining configurations of turbo-prop and jet transports and advanced fighters, interceptors and bombers.

## Career Positions at Lockheed

Lockheed's expanding development program has created a number of positions for Aerodynamics Engineers and Aerodynamicists to perform advanced work.

In addition Lockheed has positions open for Electronics Engineers, Thermodynamicists, Flight Test Analysis Engineers and Stress and Structures Engineers to perform advanced studies on such diverse projects as: Applications of nuclear energy to aircraft, turbo-prop and jet transports, bombers, trainers, supersonic fighters with speeds far surpassing those of present-day planes, and a wide range of classified activities.

**Program for Advanced Study** — To encourage members of its engineering staff in study leading to advanced degrees, Lockheed reimburses 50% of the tuition fee upon successful completion of each course relating to the engineer's field at the University of Southern California and University of California at Los Angeles. Both universities offer a wide night school curriculum in science and engineering.

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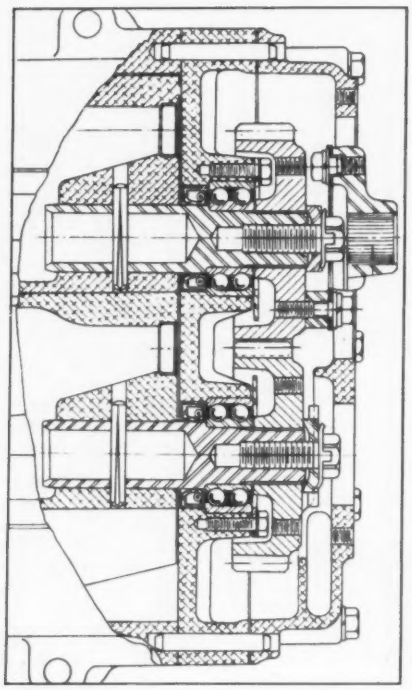
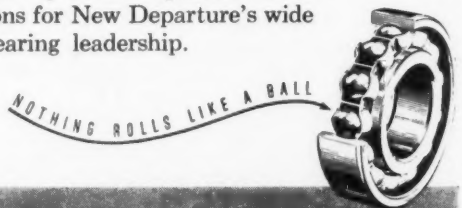
## "NEW DEPARTURES" IN SCIENCE & INVENTION

Naturally Dr. Diesel was proud of his engine. He was delighted! He'd spent the best years of his life on this "new departure." So many experiments. So many failures. He finally succeeded in 1897, and engineers everywhere acclaimed the Diesel engine.

Ever since, better and better Diesels have been built. Smoother-running, more compact, more powerful, more dependable. And New Departure has helped. For example, the double-row angular-contact **ball** bearing which supports the rotors in the GM Diesel Supercharger. This bearing was designed and developed by New Departure. It is just one of many reasons for New Departure's wide reputation for **ball** bearing leadership.



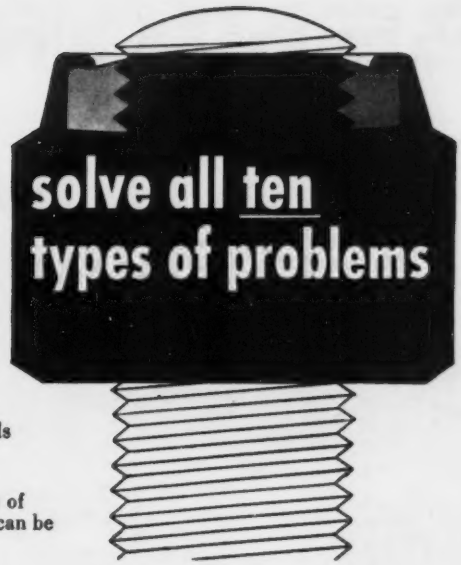
Two double-row angular-contact ball bearings provide close axial and radial location of rotors and timing gears in the GM Diesel Supercharger. This bearing type is one of many originated at New Departure.




NEW DEPARTURE
BALL BEARINGS

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

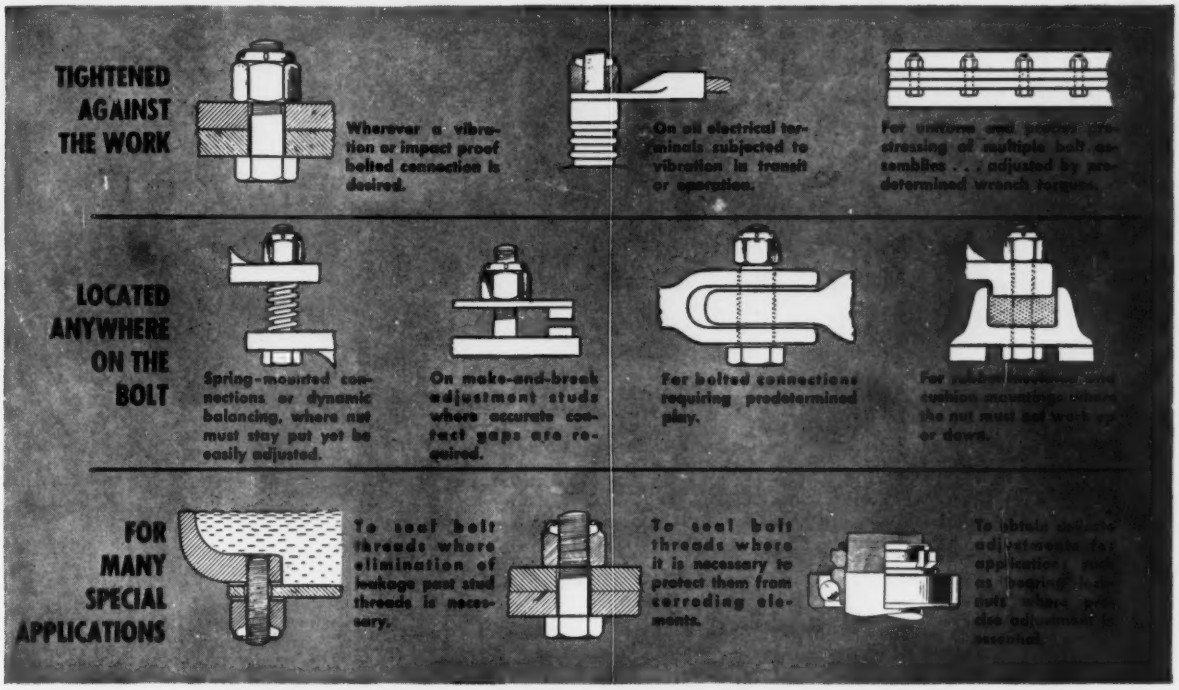
# elastic stop nuts solve all ten types of problems



Here are ten typical fastening problems. One device, the ELASTIC STOP nut, solves them all—without additional parts or operations. Deliberately undersized in relation to bolt diameter, the red elastic collar grips the bolt with a perfect fit, exerting a continuing self-locking pressure against the threads, and holding the nut securely in place at any point on the bolt. It also provides a tight seal against the bolt threads, which prevents seepage and wear-producing axial play. And because the bolt threads are protected against moisture from without, the nuts are not "frozen" to the bolt by corrosion.

ELASTIC STOP nuts stay tight, right where you put them, in spite of vibration and stress reversals. Yet they are not jammed in place, and can be removed with a wrench and reused many times.

For further information on ESNA self-locking fasteners, mail the coupon below.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# SENIOR STAFF

## *at Ramo-Wooldridge*

**The Senior Staff of The Ramo-Wooldridge Corporation,** shown above, is comprised of scientists, engineers, and science administrators with outstanding records of past performance in positions of responsibility. By means of meetings of the entire group, supplemented by frequent smaller sessions, these key men participate actively in the establishment of company plans and policies.

Existing project commitments require that the current rapid rate of expansion of the company continue throughout the coming year. Unusual opportunities, encompassing a wide variety of challenging research and development problems, exist for *additional* scientists and engineers who would like to participate in the development of a company in which, from the outset, all features of the organization and of the operational procedures are designed to be as appropriate as possible to their special needs.

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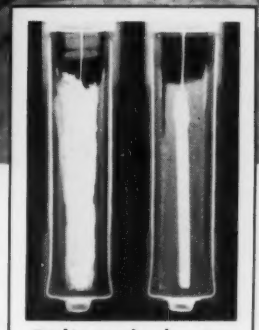
PHOTOGRAPHY AT WORK—No. 12 in a Kodak Series

# When photography peered inside... the battery shrank in size... lasted longer



Radiograph showing how anode grows in use. From such facts, National Carbon developed a battery with the largest possible anode in a small case.

**In air-depolarized hearing-aid batteries, anode size determines battery life. But anodes swell in use. How big could one be for a tiny new case? National Carbon Company used x-rays and photography and found out.**

NEW electronic developments were making hearing aids more effective, smaller, more convenient. What was needed was a power supply equally advantageous. Could this be had without sacrifice in battery life?

National Carbon Company thought so—put x-ray photography to work—and came up with a mighty midget "Eveready" with unusually long life.

Checking internal conditions like this—proving the soundness of castings and welds—inspecting the inside of "sealed-in" assemblies—are all in the day's work for photography.

In fact, graduates in the physical sciences and in engineering find photography an increasingly valuable tool in their new occupations. Its expanding use has also created many challenging opportunities at Kodak, especially in the development of large-scale chemical processes and the design of complex precision mechanical-electronic equipment. Whether you are a recent graduate or a qualified returning serviceman, if you are interested in these opportunities, write to Business & Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

**Eastman Kodak Company, Rochester 4, N. Y.**

*Looking ahead with General Electric*

# How do you measure up in leadership qualities?

**A young man who can lead** has always had a good chance of success, but his prospects were never better than now. There's a steadily growing demand in industry for men to fill top professional and management jobs . . . fellows with a special ability to work well with other people and inspire their best work. At General Electric, we're constantly on the lookout for them.

**Ten traits we look for,** above, add up to a pretty good indication of potential success in business. Not everyone has them all to a top degree, but the basic characteristics are always present and can be developed in the men we pick to help lead General Electric. We hope you can rate yourself very high on the list and find it helpful.

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